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ABSTRACT

This survey brings together information concerning the growing number of buildings utilizing solar energy and is designed to facilitate the comparison of specific characteristics of the buildings. The 66 U.S. entries are divided into five regions, arranged by state, and roughly by date within each state. Seven entries are from other countries. A separate entry for each building lists in a standard form detailed information, followed by additional comments, a bibliography, and a drawing of the building. Information listed includes building location; climatological factors; characteristics of the building, collector, and storage tank; auxiliary energy sources; heat collection and distribution methods; hot water supply; automatic controls; cooling; and performance specifications. (MLF)

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CENTER FOR ENVIRONMENTAL RESEARCH

UNIVERSITY OF OREGON EUGENE, OREGON

SURVEY OF SOLAR BUILDINGS

Robert Gray and Steven Baker

with Lucy Davis, Chris Defferding, And Ellen Tranes

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Introduction

The purpose of this survey is to bring together information concerning the growing numbers of buildings utilizing solar energy The survey is designed to facilitate the comparison of specific information about the buildings. Each building has a separate entry which first lists in a standard form the detailed information, then comments, a bibliography, and a drawing follows. The buildings are arranged by state or foreign country, and roughly by date within each state. The format of the standard list was adapted from the form used by George Löf in his general report GR/14 (S) Vol. 5 Proceedings of the U.N. Conference on New Sources of Energy, Rome, 1961. It is hoped that this survey can be used as a workbook for recording more information as it becomes available. It is intended that this survey be regularly updated as more solar buildings are designed and operated, and as more information is published. We have included a blank data sheet in the back of the survey, for those people who have additional information and would like to share it with others.

A cross indexing of the buildings by type of system follows the individual entries. It is intended that appendices to the survey will be published in the future which draw some conclusions from the comparison of these systems.

A significant observation has already been made by the authors that there are two different approaches to the use of solar energy. The one taken in the majority of the buildings is to provide a separate mechanical system which collects, stores, and delivers solar heat when needed to an otherwise normal building (active). This approach is often consciously stated by the designers of solar buildings. The other approach is to design the form, structure, and materials of the building so that they act to directly collect and use the solar heat (passive). The buildings using this approach are relatively few in number, as can be seen under the heading "Passive Systems" in the cross index. However, these few buildings are particularly interesting from the point of view of architectural design, aesthetics, and the history of architecture. This subject has been discussed in detail by Robert Gray in his thesis The Impact of Solar Energy on Architecture, September 1974, and will be further discussed in an article now in progress.

Calculation Methods

The house heat loss is the number of the Btu's heat lost per one hour per one degree F. temperature difference from inside to outside.

The design heat load is the house heat loss multiplied by the difference between the indoor design temperature and the minimum (outdoor) design temperature. If the house heat loss is not known, it can be estimated by multiplying the conservation house heat loss per square foot by the heated floor area. The conservation house heat loss is o.5 Btu/ per hour square foot heated floor area per one degree F. temperature difference inside to outside.

The average January heat load is the house heat loss multiplied by the difference between the design indoor temperature and the average January (outdoor) temperature.

The Btu required per degree day is the house heat loss multiplied by 24 hours.

The total winter demand is the Btu's required per degree day multiplied by the total number of degree days.

The heat capacity of the storage is the equivalent water weight of the storage multiplied by the useful temperature range of the storage. The useful temperature range is the normal maximum temperature minus the minimum useful temperature. If the useful temperature range is not known, it was assumed to be 65° F. = 140°-75° .

The January storage in days is the heat capacity divided by the average January daily heat load.

Calculations were made using the following conversion factors.

Conversion Factors

Water: Water is 1.0 Btu/lb. °F.
Water is 8.36 lb./gal. or 8.36 Btu/gal./°F.
Water is 62.5 lb./cu. ft. or 62.5 Btu/cu. ft. /°F.
Water is 7.5 gal./cu. ft.
1 lb. water = 5 lb. stone, thermally
1 gal water = 42.8 lb. stone, thermally
1 cu. ft. water = 3.1 cu. ft. stone, thermally

Stone: From Löf[1]: 1.5 inch diameter granite with air spaces for air circulation. Bulk density is approximately 100 lb./cu. ft. and specific heat is approximately 0.20 Btu/lb./°F.
Stone is 100 lb./cu. ft.
Stone is 0.20 Btu/lb./°F.
Stone is 20 Btu/cu. ft./°F.

Thermal Equivalents

1 lb. stone = 0.20 lb. water
1 lb. stone = 0.0239 gal. water
1 cu. ft. stone = 0.32 cu. ft. water
1 cu. ft. stone = 2.39 gal. water

Heat Capacity

water: lb. x 1.0 x Δt °F.
gal x 8.36 x Δt °F.
cu. ft. x 62.5 x Δt °F.
stone: lb. x 0.2 x Δt °F.
cu. ft. x 20 x Δt °F.

°C x 1.8 = °F - 32°F
Feet x 0.305 = meters
inches x 2.54 = centimeters
centimeters x 0.394 = inches
meters x 3.28 = feet
sq. meters x 10.76 = sq. ft.
sq. meters x 1.196 = sq. yards
cu. meters x 35.3 = cu. feet
U.S. gallons x 0.134 = cu. feet
watts = 3.413 Btu/hr.
watt-hr. = 860.5 calories
Btu = 251 calories
1 KWH = 3413 Btu
1 KWH/m^2 = 86.05 langleys = 316 Btu/sq. ft.
1 langley = 1 calorie/cm^2 = 3.687 Btu/sq. ft.
water = 62.5 lb./cu. ft. (approx.)
water = 62.428 lb./cu. ft. at 4°C, and water = 59.83 lb./cu. ft. at 100°C
brick = 120 lb./cu. ft.
concrete = 140 lb./cu. ft. (ranges from 90 to 150)
earth = 100 lb./cu. ft. (ranges from 63 to 120)

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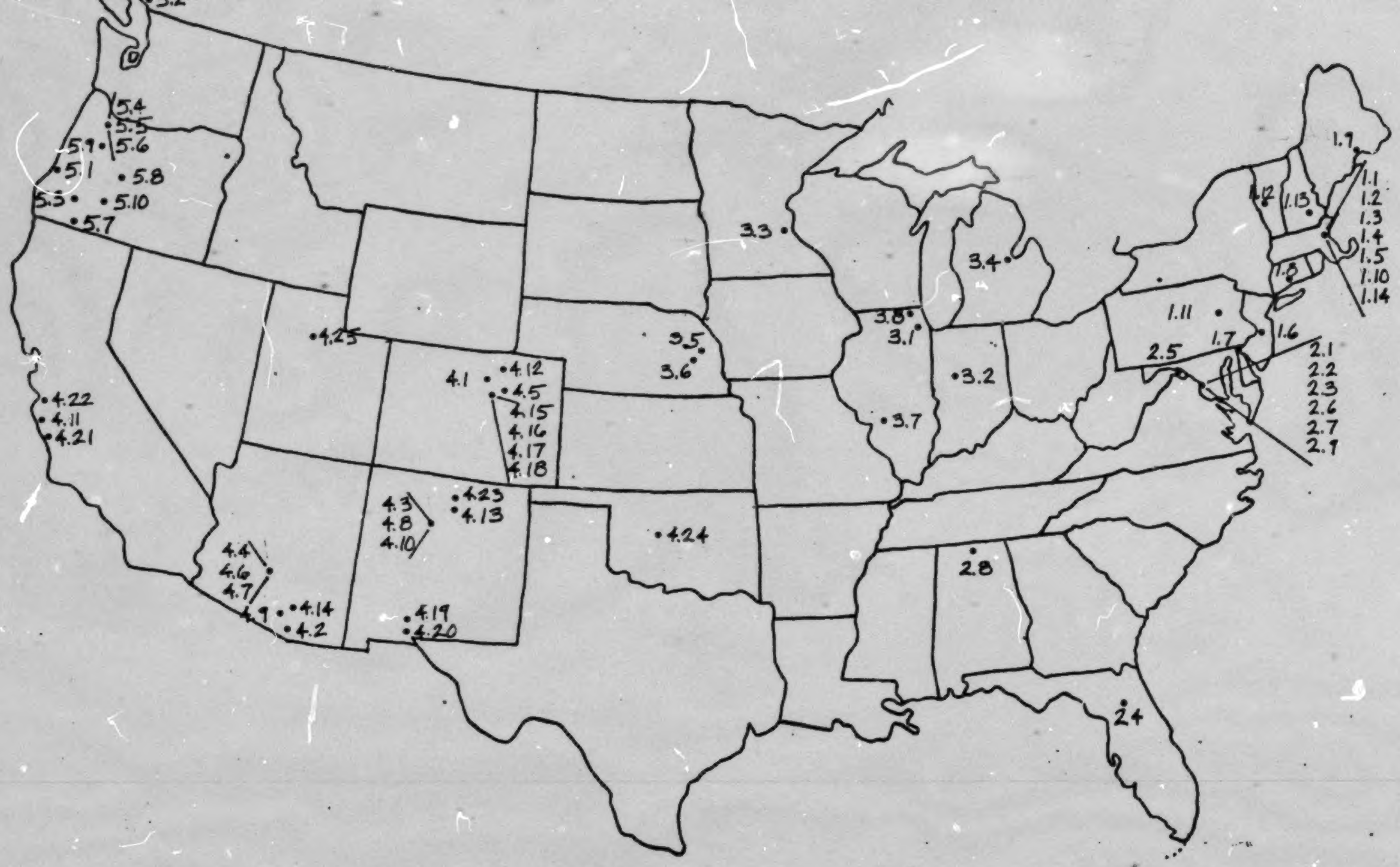
1. Löf, George, "Space Heating", in *General Report*, GR/14 (s), pp. 116-7.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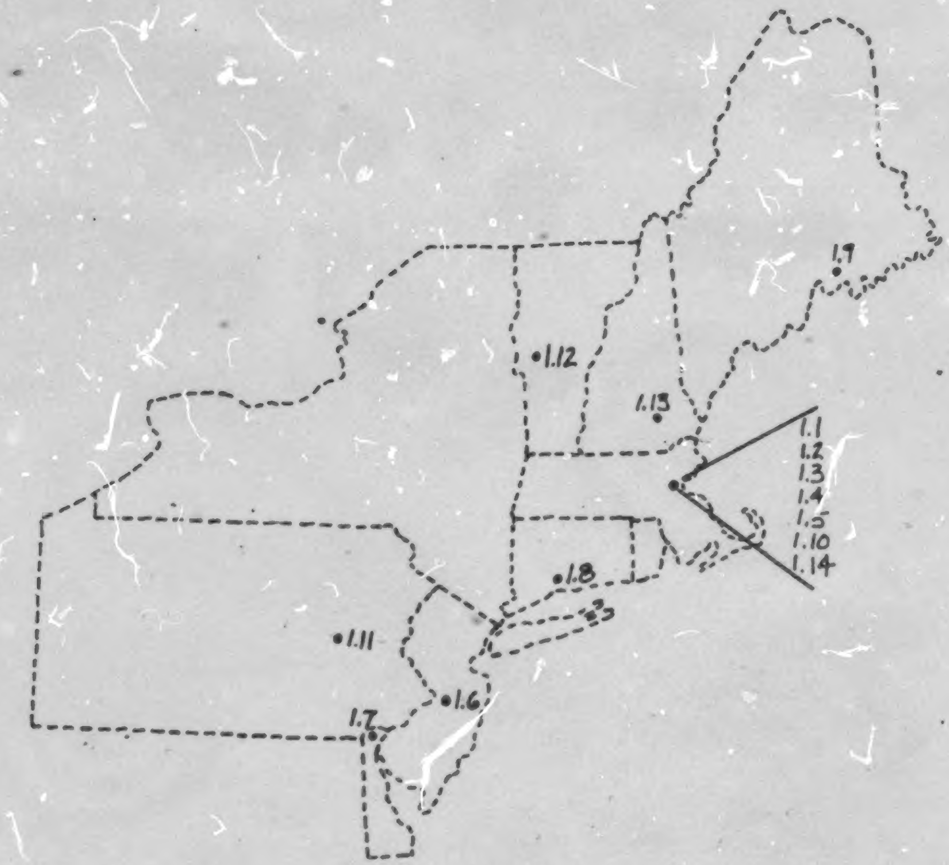
Locations of Solar Projects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NORTHEAST

1.1

Building name: MIT Solar House I
Author:
Date: 1939
Use of building: Experimental structure/ Laboratory
Duration of operation: 1939-1941 (demolished in 1941)
Location: Cambridge
    Latitude: 42° N
    Altitude: 20 ft.
    Normal degree-days/year: 5800
    Ave. Jan. solar intensity on horizontal surface: 150 ly/day
    Minimum design temperature: [illegible]° F
    Ave. Jan. temperature: 29°
Building, floor area heated: 500 ft^2 (15' x 31')
    Number of heated levels: one
    Windows:
    Walls:
    Roof:
    Indoor design temperature:
    Design (max.) heat load: 10,500 Btu/HR @ 0° F
    Ave. Jan. heat load:
    Btu required per degree day:
    Total winter demand:
Collector, type, heat transfer fluid: water heating
    Position, orientation, tilt above horizontal: 30° slope, south facing
    Area: 360 ft^2 net (400 ft^2)
    Reflector, area and slope: none
    Type of heat transfer surface: copper tube soldered to copper sheet
    Glazing: triple glazing
    Cost:
    Freeze protection: draining collector
Storage, type: water
    Volume: 17,400 gallon
    Weight:
    Water equivalent:
    Container: steel tank occupying entire basement insulated by 2 ft. of insulation
    Heat capacity:
    Normal maximum temperature: 195° F (summer)
    Jan. storage in days:
Auxiliary energy supply, type: none
    Capacity:
    Mode of supply to system:
Heat collection and distribution:
    Transfer to storage: circulating water
    Motor requirement:
    Transfer to rooms: air blown over tank top
    Motor requirement:
    Collector flow rate:
    House flow rate:
Hot water supply:
    Auxiliary heat:
    Solar source:
    Transfer means:
Automatic controls:
    Collector and storage thermostats:
    Automatic control of auxiliary:
    Automatic valves and dampers:
    Heating direct from collector:
    Automatic data recording:
    Pyroheliometer on site: yes
Cooling: none
    Heat disposal method:
    Auxiliary cooling:
    Power required:
    Heat removal from rooms:
Performance:
    Period: 1939-1941
    Ave. collector efficiency while operating:
    Ave. collector efficiency, total radiation:
    Total winter heat supply by solar:
    Auxiliary energy supply: none
    Heat equivalent of auxiliary:
    Percent load supplied by solar: 100%
    Expected (theoretical) performance:

Other comments:

Solar Heat Collector operated through the year. The minimum storage temp. in winter was 125° F. Problems with tank insulation becoming water logged, water leaks. The possibility of storing summer heat for winter use was found not economical.

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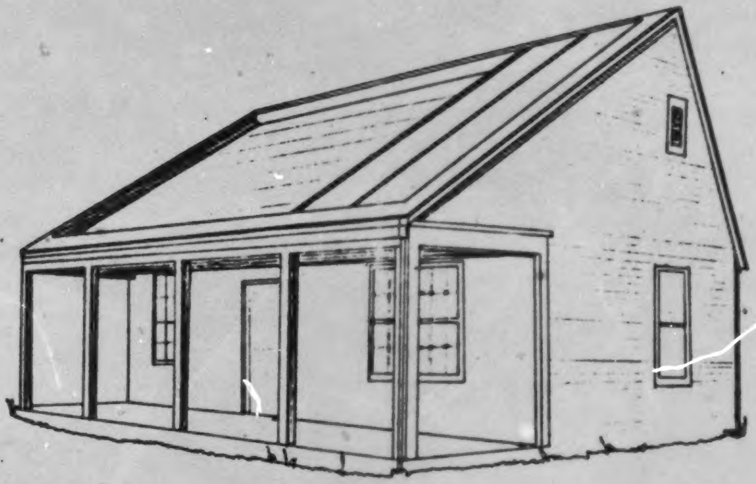

MIT SOLAR HOUSE I

- **Building name:** MIT Solar House II
- **Author:** A. G. H. Dietz, H. C. Hottel, et al
- **Date:** 1947
- **Use of building:** laboratory
- **Duration of operation:** 1947-1948, then converted to MIT Solar House III
- **Location:** Cambridge, Mass.
  - **Latitude:** 42° N
  - **Altitude:** 20 Ft.
  - **Normal degree-days/year:** 5636
  - **Ave. Jan. solar intensity on horizontal surface:** 150 ly/Day
  - **Minimum design temperature:**
  - **Ave. Jan. temperature:** 29°
- **Building, floor area heated:** 600 S. F., (14 ft. x 44 ft.)
  - **Number of heated levels:** one
  - **Windows:** some double glazed, some triple glazed
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:**
  - **Design (max.) heat load:**
  - **Ave. Jan. heat load:**
  - **Btu required per degree day:**
  - **Total winter demand:**
- **Collector, type, heat transfer fluid:** some contained water, some eutectic salt
  - **Position, orientation, tilt above horizontal:** black faced verticl storage tanks were placed behind verticle south facing glass wall
  - **Area:** covered most of 44 ft. long verticle south wall
  - **Reflector, area and slope:** none
  - **Type of heat transfer surface:** tank wall
  - **Glazing:** some double, some triple, with shades drawn at night between glass and tank
  - **Cost:**
  - **Freeze protection:** inside heated room
- **Storage, type:** tanks stand behind south glass wall and their outer wall is the collection surface, some tanks contain water, and others eutectic
  - **Volume:**
  - **Weight:**
  - **Water equivalent:**
  - **Container:**
  - **Heat capacity:**
  - **Normal maximum temperature:**
  - **Jan. storage in days:**
- **Auxiliary energy supply, type:**
  - **Capacity:**
  - **Mode of supply to system:**
- **Heat collection and distribution:**
  - **Transfer to storage:** direct
  - **Motor requirement:** N. A.
  - **Transfer to rooms:** direct
  - **Motor requirement:** N. A.
  - **Collector flow rate:** N. A.
  - **House flow rate:**
- **Hot water supply:**
  - **Auxiliary heat:**
  - **Solar source:**
  - **Transfer means:**
- **Automatic controls:**
  - **Collector and storage thermostats:**
  - **Automatic control of auxiliary:**
  - **Automatic valves and dampers:**
  - **Heating direct from collector:**
  - **Automatic data recording:**
  - **Pyrheliometer on site:**
- **Cooling:**
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:**
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:**
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:**
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:**

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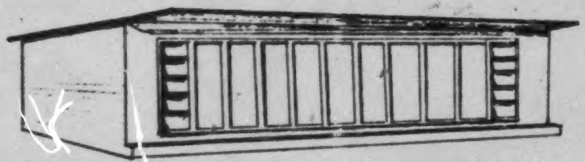

MIT SOLAR HOUSE II

1.3

- Building name: MIT Solar House III
- Author: Edmund L. Czapek
- Date: Constructed in 1949 (remodeled from Solar House II)
- Use of building: Residence/laboratory
- Duration of operation: Demolished in 1956 due to fire
- Location: Cambridge, Mass.
  - Latitude: 42°N
  - Altitude: Approx. 20 ft.
  - Normal degree-days/year: 5800
  - Ave. Jan. solar intensity on horizontal surface: 150 ly/day
  - Minimum design temperature: 0°F
  - Ave. Jan. temperature: 29°F
- Building, floor area heated: 650 sqft.
  - Number of heated levels: One
  - Windows: double-glazed (see comments)
  - Walls:
  - Roof:
  - Indoor design temperature: 68°F
  - Design (max.) heat load: 19,550 BTU/H (b)
  - Ave. Jan. heat load: 11,212 BTU/H (b)
  - Btu required per degree day: 6,900 Btu
  - Total winter demand: 40,020,000 BTU (b)
- Collector, type, heat transfer fluid: Water heating
  - Position, orientation, tilt above horizontal: South roof, 57° slope
  - Area: 400 sqft. (9' x 46-1/2')
  - Reflector, area and slope: Aluminum horizontal reflector (3' x 46-1/2')
  - Type of heat transfer surface: Copper piping soldered to copper sheet; 3/8" tube, at 6" o.c.
  - Glazing: Two glass sheets
  - Cost:
  - Freeze protection:
- Storage, type: Water
  - Volume: 1,200 gal. (v.s 1,500 gal., 3' dia x 30' = 1,600 gal.)
  - Weight: 5 tons = 10,000 lb.
  - Water equivalent: 1,200 gal.
  - Container: Steel tank in attic (2-1/2' diameter x 36' long)
  - Heat capacity: 650,000 Btu(a)
  - Normal maximum temperature:
  - Jan. storage in days: 2 days
- Auxiliary energy supply, type: Immersion type electric resistance heaters
  - Capacity: 2 - 3.5 kw
  - Mode of supply to system:
- Heat collection and distribution:
  - Transfer to storage: Circulating water
  - Motor requirement: Water pump
  - Transfer to rooms: Radiant ceiling
  - Motor requirement: Water pump
  - Collector flow rate:
  - House flow rate:
- Hot water supply:
  - Auxiliary heat:
  - Solar source:
  - Transfer means:
- Automatic controls: Full
  - Collector and storage thermostats: Collector and storage thermostats
  - Automatic control of auxiliary: Yes
  - Automatic valves and dampers: One mixing valve
  - Heating direct from collector: No
  - Automatic data recording: Yes
  - Pyroheliometer on site: Yes
- Cooling: No
  - Heat disposal method:
  - Auxiliary cooling:
  - Power required:
  - Heat removal from rooms:
- Performance:
  - Period: 1948-1949, 1949-1950 (winter)
  - Ave. collector efficiency while operating: 37%
  - Ave. collector efficiency, total radiation: 30%
  - Total winter heat supply by solar:
  - Auxiliary energy supply:
  - Heat equivalent of auxiliary:
  - Percent load supplied by solar: 91% (1948-1949); 81% (1949-1950); 75% to 85% in four mid winter months
  - Expected (theoretical) performance:

Other comments:

All windows on south side of the house are triple-glazed except for one panel which serves as a sliding door and is double-glazed. The remaining windows on the other sides of the house are double-glazed.

(a)Calculated by R. Gray, at Δt = 65°F

(b)Calculated by Q. Bruhn

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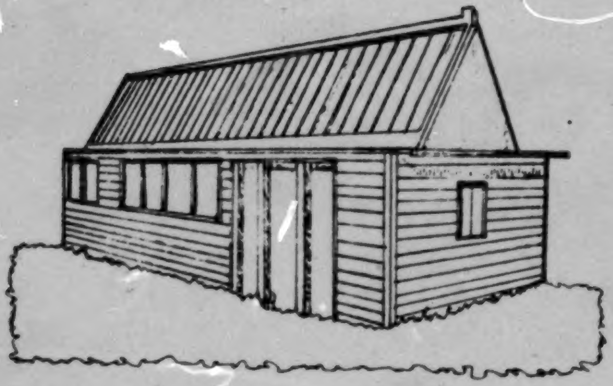

MIT SOLAR HOUSE III

1.4

Building name: Peabody House
Author: Dr. Maria Telkes, Eleanor Raymond, architect
Date: Constructed in 1949
Use of building: Residence
Duration of operation: In 1953 house was enlarged and solar heating system removed
Location: Dover, Mass.
Latitude: 42°N
Altitude: Approx. 700 ft.
Normal degree-days/year: 5800
Ave. Jan. solar intensity on horizontal surface: 150 ly/day
Minimum design temperature: -10°F
Ave. Jan. temperature: 29°F
Building, floor area heated: 850 sqft.
Number of heated levels: One
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Air heating
Position, orientation, tilt above horizontal: South vertical wall
Area: 10' high x 50' long, 500 sqft.
Reflector, area and slope: None
Type of heat transfer surface: Sheet metal
Glazing: Double glass
Cost:
Freeze protection: Draining collector
Storage, type: Heat of fusion (Glauber's salt)
Volume: 700 - 5 gal. cans
Weight: 20 tons
Water equivalent:
Container: Bin containing metal drums of Glauber's salt (attic)
Heat capacity:
Normal maximum temperature:
Jan. storage in days: 10 (1), 6(5)
Auxiliary energy supply, type: None
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: Forced air
Motor requirement: Blower
Transfer to rooms: Radiation and forced air
Motor requirement: Blower
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling: Yes
Heat disposal method: Night air blown through storage
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar: 95% estimated
Expected (theoretical) performance: 100% solar heated

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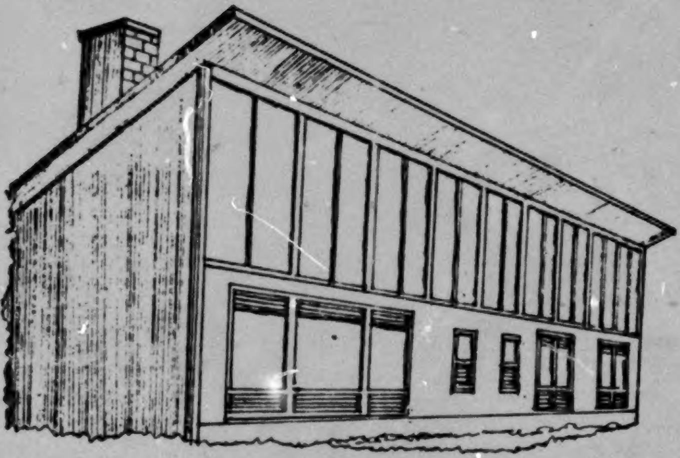
also see Technology Review, April, 1949.



PEABODY HOUSE

1.5

- **Building name:** MIT Solar House IV
- **Author:** Engrebretson
- **Date:** Constructed in 1959
- **Use of building:** Residence
- **Duration of operation:** Two years (maintenance problems)
- **Location:** Lexington, Mass.
  - **Latitude:** 42°N
  - **Altitude:** Approx. 200 ft.
  - **Normal degree-days/year:** Approx. 6000
  - **Ave. Jan. solar intensity on horizontal surface:** 160 ly/day
  - **Minimum design temperature:** -10°F
  - **Ave. Jan. temperature:** 29°F
- **Building, floor area heated:** 1,450 sqft.
  - **Number of heated levels:** Two (first storey partially below ground)
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:** 65°
  - **Design (max.) heat load:** 37,000 Btu/hr
  - **Ave. Jan. heat load:** 18,000 Btu/hr
  - **Btu required per degree day:** 12,000 Btu
  - **Total winter demand:** 67,000,000 Btu
- **Collector, type, heat transfer fluid:** Water heating
  - **Position, orientation, tilt above horizontal:** South roof, 60° slope
  - **Area:** 640 sqft. (16' x 40')
  - **Reflector, area and slope:** None
  - **Type of heat transfer surface:** Copper tubing mechanical connected to sheet aluminum
  - **Glazing:** Double low-iron content glass
  - **Cost:** $6,500 for whole system
  - **Freeze protection:** draining collector
- **Storage, type:** Water
  - **Volume:** 1,500 gal.
  - **Weight:** 6.2 tons = 12,500 lb.
  - **Water equivalent:** 1,500 gal.
  - **Container:** Steel tank, 5' dia. x 9'
  - **Heat capacity:** Approx. .4 million Btu
  - **Normal maximum temperature:** Approx. 120°F
  - **Jan. storage in days:**
- **Auxiliary energy supply, type:** Yes, oil furnace
  - **Capacity:** Full load
  - **Mode of supply to system:** Heat water in auxiliary storage
- **Heat collection and distribution:**
  - **Transfer to storage:** Circulating water
  - **Motor requirement:**
  - **Transfer to rooms:** Heat exchange to air
  - **Motor requirement:** Water pump; air fan
  - **Collector flow rate:** 10.7 gal/min
  - **House flow rate:** Water at 3.6 gal/min; air at 850 cfm
- **Hot water supply:** Yes, preheat
  - **Auxiliary heat:** Oil furnace
  - **Solar source:** Hot water from collector
  - **Transfer means:** Coil in storage tank
- **Automatic controls:** Full
  - **Collector and storage thermostats:** Collector and storage
  - **Automatic control of auxiliary:** Yes
  - **Automatic valves and dampers:** One mixing valve
  - **Heating direct from collector:** No
  - **Automatic data recording:** Yes
  - **Pyroheliometer on site:** Yes
- **Cooling:** None
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:**
  - **Period:** 1960-1961 (October - March)
  - **Ave. collector efficiency while operating:** 40.8%
  - **Ave. collector efficiency, total radiation:** 32.6%
  - **Total winter heat supply by solar:** 38.1 million Btu(a)
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:** 28.9 million Btu(a)
  - **Percent load supplied by solar:** 56.8%(a)
  - **Expected (theoretical) performance:** 75%

Other comments:

Original glazing deteriorated in three years.

(a) Excluding water heating. Corresponding values including water heating are 47.4 million Btu, 36.4 million Btu, and 56.6%.

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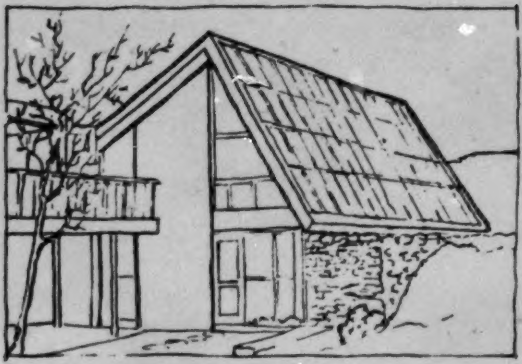

MIT SOLAR HOUSE IV

1.6

Building name: Princeton Solar Laboratory
Author: Olgyay, Aladar; Curtis Wright Corp.
Date: 1959
Use of building: Laboratory
Duration of operation: Several years, then sold and demolished
Location: Princeton, N.J.
  Latitude: 40°N
  Altitude: Approx. 50 ft.
  Normal degree-days/year: 5100
  Ave. Jan. solar intensity on horizontal surface: 160 ly/day
  Minimum design temperature: Approx. 10°F
  Ave. Jan. temperature: 32°F
Building, floor area heated: 1,200 sqft.
  Number of heated levels: One
  Windows:
  Walls:
  Roof:
  Indoor design temperature: 70°
  Design (max.) heat load: 25,000 Btuh.
  Ave. Jan. heat load: 12,500 Btuh.
  Btu required per degree day: Approx. 9,000
  Total winter demand: 45,900,000 BTU (b)
Collector, type, heat transfer fluid: Air heating
  Position, orientation, tilt above horizontal: Vertical, south wall
  Area: 600 sqft.
  Reflector, area and slope:
  Type of heat transfer surface: Metal sheet
  Glazing: Double glazing
  Cost:
  Freeze protection:
Storage, type: Heat-of-fusion, eutectic salt
  Volume: 275 cuft.
  Weight:
  Water equivalent:
  Container:
  Heat capacity: 2.5 million BTU
  Normal maximum temperature:
  Jan. storage in days:
Auxiliary energy supply, type: None
  Capacity: N.A.
  Mode of supply to system: N.A.
Heat collection and distribution:
  Transfer to storage: Hot air to heat-of-fusion
  Motor requirement:
  Transfer to rooms: House air through storage
  Motor requirement:
  Collector flow rate:
  House flow rate:
Hot water supply: None
  Auxiliary heat: N.A.
  Solar source: N.A.
  Transfer means: N.A.
Automatic controls: Yes
  Collector and storage thermostats: Collector
  Automatic control of auxiliary: N.A.
  Automatic valves and dampers:
  Heating direct from collector:
  Automatic data recording:
  Pyroheliometer on site:
Cooling: No
  Heat disposal method: N.A.
  Auxiliary cooling: N.A.
  Power required: N.A.
  Heat removal from rooms: N.A.
Performance:
  Period:
  Ave. collector efficiency while operating: 46.5% December-January[a]
  Ave. collector efficiency, total radiation:
  Total winter heat supply by solar:
  Auxiliary energy supply:
  Heat equivalent of auxiliary:
  Percent load supplied by solar:
  Expected (theoretical) performance:

Other Comments:

(a) No supporting data attached.

(b) Calculated by Q. Bruhn

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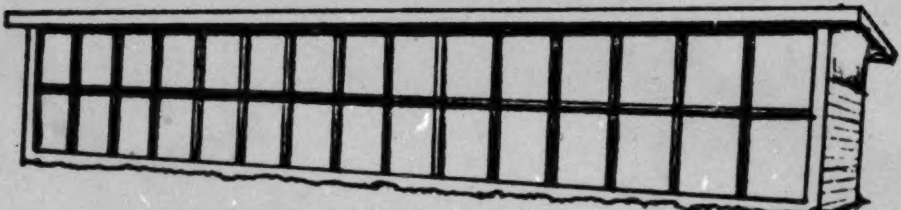

PRINCETON SOLAR LABORATORY

1.7

- **Building name:** Solar I
- **Author:** K. Boer, University of Delaware
- **Date:** July, 1973
- **Use of building:** Residence/laboratory
- **Duration of operation:**
- **Location:** Newark, Delaware
    - **Latitude:** 37.5°N
    - **Altitude:** Approx. 100 - 200 ft.
    - **Normal degree-days/year:** 4739 (Philadelphia, Pa.)
    - **Ave. Jan. solar intensity on horizontal surface:** 180 ly/Day
    - **Minimum design temperature:** 0°F
    - **Ave. Jan. temperature:** 33°F
- **Building, floor area heated:** 1400 sqft.
    - **Number of heated levels:** One (second storey unfinished)
    - **Windows:**
    - **Walls:**
    - **Roof:**
    - **Indoor design temperature:**
    - **Design (max.) heat load:**
    - **Ave. Jan. heat load:**
    - **Btu required per degree day:**
    - **Total winter demand:**
- **Collector, type, heat transfer fluid:** Air heating
    - **Position, orientation, tilt above horizontal:** South roof (45°) and south wall
    - **Area:** 960 sqft. (wall - 192 sqft.; roof - 768 sqft.)
    - **Reflector, area and slope:** None
    - **Type of heat transfer surface:** Aluminum sheet or cadmium sulfide cells
    - **Glazing:** Acrylic plexiglass, Abcite-coated, one layer over photovoltaic cells on roof, two layers on south wall over aluminum
    - **Cost:** $130,000 for entire house
    - **Freeze protection:**
- **Storage, type:** Heat-of-fusion
    - **Volume:** 216 cuft. at 120°F, 24 cuft. at 75°F, 45 cuft. at 55°F
    - **Weight:** 12,000 lb. total; 8,000 lb. at 120°F, 1,400 lb. at 75°F, 2,600 lb. at 55°F
    - **Water equivalent:**
    - **Container:** Two bins - 120°F and 50°F salts; 75°F salts
    - **Heat capacity:** 120°F salts (1,000,000 Btu), 75°F salts (200,000 Btu)
    - **Normal maximum temperature:**
    - **Jan. storage in days:**
- **Auxiliary energy supply, type:** Yes, heat pump, electrical resistance heating
    - **Capacity:** Heat pump (3 H.P.), 75°F store to 120°F store; electric resistance (9 kw) to main store
    - **Mode of supply to system:** Heat house air
- **Heat collection and distribution:**
    - **Transfer to storage:** Hot air by blower
    - **Motor requirement:** 2 H.P. on roof collector, 1/2 H.P. on south wall collector
    - **Transfer to rooms:** Conventional ductwork, forced hot air
    - **Motor requirement:** 1/2 H.P. blower
    - **Collector flow rate:** 3600 cfm roof collector, 1200 cfm wall collector
    - **House flow rate:**
- **Hot water supply:**
    - **Auxiliary heat:** Electric hot water heater
    - **Solar source:**
    - **Transfer means:**
- **Automatic controls:** Full
    - **Collector and storage thermostats:** Collector and storage
    - **Automatic control of auxiliary:** Yes
    - **Automatic valves and dampers:** 17 pneumatic motorized dampers
    - **Heating direct from collector:** Yes
    - **Automatic data recording:**
    - **Pyrheliometer on site:**
- **Cooling:** Yes
    - **Heat disposal method:** Heat pump to outside air at night, or to 75°F store
    - **Auxiliary cooling:** Heat pump and blower
    - **Power required:** 3 H.P. heat pump and 1/2 H.P. blower
    - **Heat removal from rooms:** House air through storage
- **Performance:**
    - **Period:**
    - **Ave. collector efficiency while operating:**
    - **Ave. collector efficiency, total radiation:**
    - **Total winter heat supply by solar:**
    - **Auxiliary energy supply:**
    - **Heat equivalent of auxiliary:**
    - **Percent load supplied by solar:**
    - **Expected (theoretical) performance:** 80% of total energy demand, 80% from heat, 90% winter heat

Other comments:

6% of solar collector to be initially covered with cadmium sulfide solar cells which will charge 20 - 12 volt 20 ampere hour lead acid batteries. Collector to be covered with copper sulfide selective black surface. Can charge storage batteries from the utility company during off-peak hours (night) for peak saving; will disconnect from utilities during peak unless electric storage drops below 40% charge.

The pneumatic control system was designed by Harold Kiefer of Johnson Science Company, Philadelphia, Pa. Dick Mouse of I.D. Griffith was the mechanical contractor.

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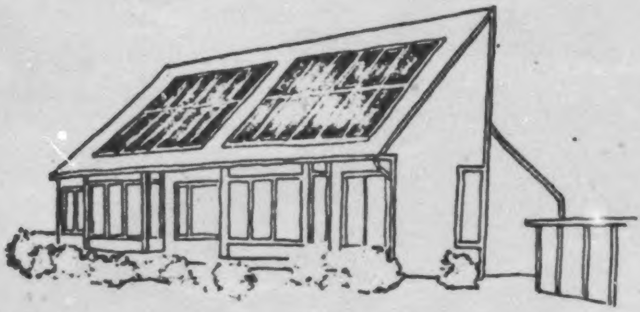

BOER SOLAR 1

1.8

- **Building name:** (Owner confidential)
- **Author:** Donald Watson, architect; Everett Barber Jr., engineer
- **Date:** Constructed winter, 1973-1974
- **Use of building:** Residence, three bedroom, $60,000, 1900 sqft.
- **Duration of operation:**
- **Location:** Connecticut Coast, Long Island Sound
  - **Latitude:** 41-1/4°N
  - **Altitude:** 10 ft.
  - **Normal degree-days/year:** 6026 (New Haven, Conn.)
  - **Ave. Jan. solar intensity on horizontal surface:** 150 ly/Day
  - **Minimum design temperature:** 0°F
  - **Ave. Jan. temperature:** 29°F (New Haven, Conn.)
- **Building, floor area heated:** 1900 sqft.
  - **Number of heated levels:** 1-1/2
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:**
  - **Design (max.) heat load:**
  - **Ave. Jan. heat load:**
  - **Btu required per degree day:**
  - **Total winter demand:**
- **Collector, type, heat transfer fluid:** Water with ethylene glycol (antifreeze)
  - **Position, orientation, tilt above horizontal:** Roof, south facing, 45° tilt, 3 rows
  - **Area:** 456 sqft., 38 Sunworks panels, 2' x 6'
  - **Reflector, area and slope:** None
  - **Type of heat transfer surface:** 17 mil copper plate, selective black a/e = 5, 1/4" dia. copper tubes soldered 5" o.c.
  - **Glazing:** One layer glass
  - **Cost:** $3,500 over conventional = 6% of total, cuts fuel bills $300-$600 annually
  - **Freeze protection:**
- **Storage, type:** Water
  - **Volume:** 1,500 gal.
  - **Weight:** 12,500 lb.
  - **Water equivalent:** Same
  - **Container:** Steel tank, 5' dia. x 12'
  - **Heat capacity:** 813,000 Btu
  - **Normal maximum temperature:** 140°F
  - **Jan. storage in days:** About two days
- **Auxiliary energy supply, type:** Yes, oil
  - **Capacity:**
  - **Mode of supply to system:** Oversized water heater with pump
- **Heat collection and distribution:**
  - **Transfer to storage:** Heat exchanger, from collector antifreeze to storage water
  - **Motor requirement:** Pump on collector
  - **Transfer to rooms:** Fan-coil unit - water to house air
  - **Motor requirement:** Pump and fan
  - **Collector flow rate:**
  - **House flow rate:**
- **Hot water supply:**
  - **Auxiliary heat:**
  - **Solar source:**
  - **Transfer means:**
- **Automatic controls:**
  - **Collector and storage thermostats:**
  - **Automatic control of auxiliary:**
  - **Automatic valves and dampers:**
  - **Heating direct from collector:**
  - **Automatic data recording:**
  - **Pyroheliometer on site:**
- **Cooling:** Absorption cooling machine shown in diagram, cools storage
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:** From room air through fan coil unit to cool storage to cooling machine
- **Performance:**
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:**
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:**
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:** Predicted 55% of annual heat (from collector = 20% floor area) and all hot water

Other comments:

South wall is 60% on first floor, 60% window on second floor, double glazed with overhangs for summer shading.

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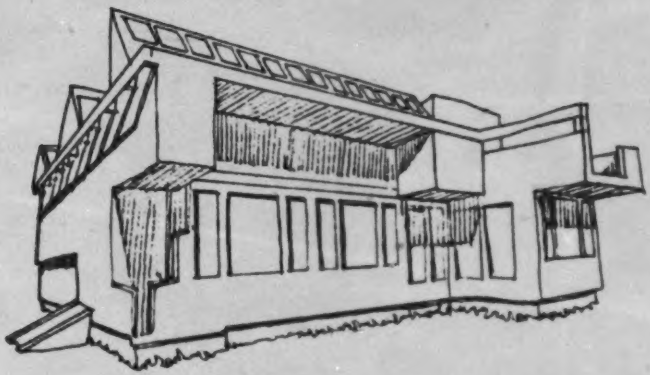

WATSON-BARBER SOLAR HOUSE

1.9

- Building name: College of the Atlantic
- Author: Edward Larrabee Barnes, Hildegarde Bergeni project architect, Lega Associates, mechanical engineer, Windworks windpwoer consultants
- Date: In design process 1974
- Use of building: College of environmental studies
- Duration of operation:
- Location: Bar Harbor, Maine
  - Latitude: 44°N
  - Altitude: Approx. 100 ft.
  - Normal degree-days/year: 8445 (Eastport)
  - Ave. Jan. solar intensity on horizontal surface: 130 ly/Day
  - Minimum design temperature: -15°F (Eastport)
  - Ave. Jan. temperature: 32°F (Eastport)
- Building, floor area heated:
  - Number of heated levels:
  - Windows:
  - Walls:
  - Roof:
  - Indoor design temperature:
  - Design (max.) heat load:
  - Ave. Jan. heat load:
  - Btu required per degree day:
  - Total winter demand:
- Collector, type, heat transfer fluid:
  - Position, orientation, tilt above horizontal:
  - Area:
  - Reflector, area and slope:
  - Type of heat transfer surface:
  - Glazing:
  - Cost:
  - Freeze protection:
- Storage, type:
  - Volume:
  - Weight:
  - Water equivalent:
  - Container:
  - Heat capacity:
  - Normal maximum temperature:
- Auxiliary energy supply, type:
  - Capacity:
  - Mode of supply to system:
- Heat collection and distribution:
  - Transfer to storage:
  - Motor requirement:
  - Transfer to rooms:
  - Motor requirement:
  - Collector flow rate:
  - House flow rate:
- Hot water supply:
  - Auxiliary heat:
  - Solar source:
  - Transfer means:
- Automatic controls:
  - Collector and storage thermostats:
  - Automatic control of auxiliary:
  - Automatic valves and dampers:
  - Heating direct from collector:
  - Automatic data recording:
  - Pyroheliometer on site:
- Cooling:
  - Heat disposal method:
  - Auxiliary cooling:
  - Power required:
  - Heat removal from rooms:
- Performance:
  - Period:
  - Ave. collector efficiency while operating:
  - Ave. collector efficiency, total radiation:
  - Total winter heat supply by solar:
  - Auxiliary energy supply:
  - Heat equivalent of auxiliary:
  - Percent load supplied by solar:
  - Expected (theoretical) performance:

Other comments:

Solar Heating:
a) Insulated skylight roof with shading devices and polarizing screen
b) Equipment for solar domestic water heating and solar cooking

Wind Power: Three water pumping windmills
100 of 20 ft. diameter electric power windmills

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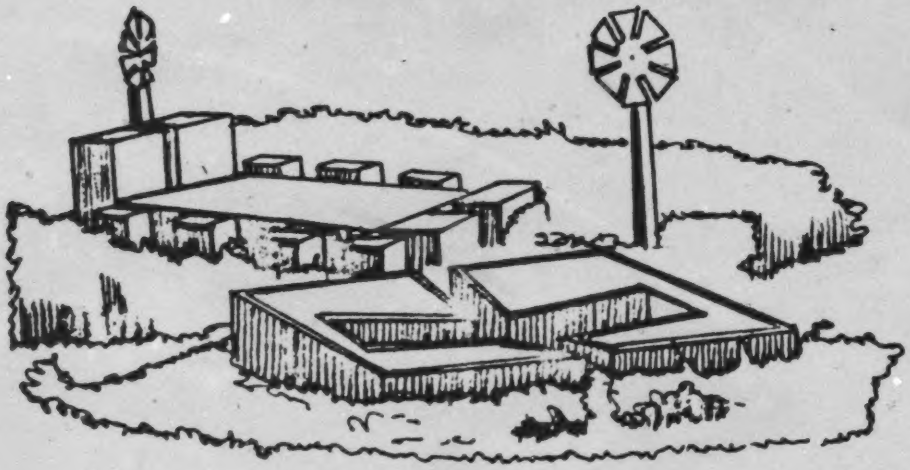

COLLEGE OF THE ATLANTIC

1.10

Building name: Grover Cleveland Junior High School
Author: General Electric Company (Space Division, Valley Forge, Pennsylvania)
Date: 1974, on a $354,000 NSF grant
Use of building: Solar system added to roof of existing junior high school
Duration of operation:
Location: Dorchester, Mass.
Latitude: 42°N
Altitude: Approx. 200 ft.
Normal degree-days/year: 5800
Ave. Jan. solar intensity on horizontal surface: 150 ly/day
Minimum design temperature: 0°F
Ave. Jan. temperature: 29°F
Building, floor area heated:
Number of heated levels:
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Water heating
Position, orientation, tilt above horizontal: On roof, facing south, 45° slope, 3 rows
Area: 4,500 sqft.
Reflector, area and slope: None
Type of heat transfer surface: Aluminum Roll-Bond, by Olin Brass, Inc., 4' x 8' panels
Glazing: Two layers Lexan (a poly-carbonate plastic)
Cost: $354,000 NSF grant
Freeze protection: Antifreeze in collector
Storage, type: Water storage
Volume: 2,000 gal.
Weight: 16,700 lb.
Water equivalent: Same
Container:
Heat capacity: 1.1 million Btu(a)
Normal maximum temperature:
Jan. storage in days:
Auxiliary energy supply, type: Electric
Capacity:
Mode of supply to system: Hot air
Heat collection and distribution:
Transfer to storage: Pump collector to storage or heat exchange
Motor requirement:
Transfer to rooms: Water-air heat exchanger to room
Motor requirement: Pump water storage-exchanger, fan for room air
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling:
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary: Up to 20% of school's heating needs are supplied by solar
Percent load supplied by solar:
Expected (theoretical) performance:

Other comments:

[a]Calculated by R. Gray, at $\Delta t = 65°F$.

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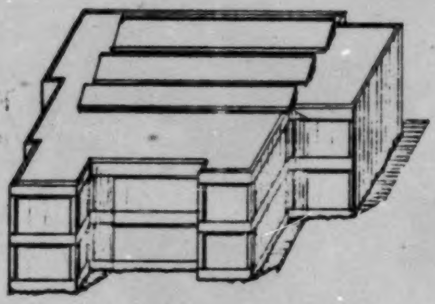

GROVER CLEVELAND JR. HIGH SCHOOL

1.10

- **Building name:** Grover Cleveland Junior High School
- **Author:** General Electric Company (Space Division, Valley Forge, Pennsylvania)
- **Date:** 1974, on a $354,000 NSF grant
- **Use of building:** Solar system added to roof of existing junior high school
- **Duration of operation:**
- **Location:** Dorchester, Mass.
  - **Latitude:** 42°N
  - **Altitude:** Approx. 200 ft.
  - **Normal degree-days/year:** 5800
  - **Ave. Jan. solar intensity on horizontal surface:** 150 ly/day
  - **Minimum design temperature:** 0°F
  - **Ave. Jan. temperature:** 29°F
- **Building, floor area heated:**
  - **Number of heated levels:**
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:**
  - **Design (max.) heat load:**
  - **Ave. Jan. heat load:**
  - **Btu required per degree day:**
  - **Total winter demand:**
- **Collector, type, heat transfer fluid:** Water heating
  - **Position, orientation, tilt above horizontal:** On roof, facing south, 45° slope, 3 rows
  - **Area:** 4,500 sqft.
  - **Reflector, area and slope:** None
  - **Type of heat transfer surface:** Aluminum Roll-Bond, by Olin Brass, Inc., 4' x 8' panels
  - **Glazing:** Two layers Lexan (a poly-carbonate plastic)
  - **Cost:** $354,000 NSF grant
  - **Freeze protection:** Antifreeze in collector
- **Storage, type:** Water storage
  - **Volume:** 2,000 gal.
  - **Weight:** 16,700 lb.
  - **Water equivalent:** Same
  - **Container:**
  - **Heat capacity:** 1.1 million Btu(a)
  - **Normal maximum temperature:**
  - **Jan. storage in days:**
- **Auxiliary energy supply, type:** Electric
  - **Capacity:**
  - **Mode of supply to system:** Hot air
- **Heat collection and distribution:**
  - **Transfer to storage:** Pump collector to storage or heat exchange
  - **Motor requirement:**
  - **Transfer to rooms:** Water-air heat exchanger to room
  - **Motor requirement:** Pump water storage-exchanger, fan for room air
  - **Collector flow rate:**
  - **House flow rate:**
- **Hot water supply:**
  - **Auxiliary heat:**
  - **Solar source:**
  - **Transfer means:**
- **Automatic controls:**
  - **Collector and storage thermostats:**
  - **Automatic control of auxiliary:**
  - **Automatic valves and dampers:**
  - **Heating direct from collector:**
  - **Automatic data recording:**
  - **Pyroheliometer on site:**
- **Cooling:**
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:**
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:**
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:** Up to 20% of school's heating needs are supplied by solar
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:**

Other Comments:

[a]Robert Romancheck, supervisor of energy research and technical services. Robert Deppen, energy conservation consultant.

[b]Auxiliary heat sources: air source heat pump, fireplace with outside air supply and heat exchange in flue, waste water heat exchanger, refrigerator and dryer heat exchanger.

[c]House insulated with triple glazing, polyurethane foam to seal around windows and doors, polystyrene tongue-in-groove sheathing.

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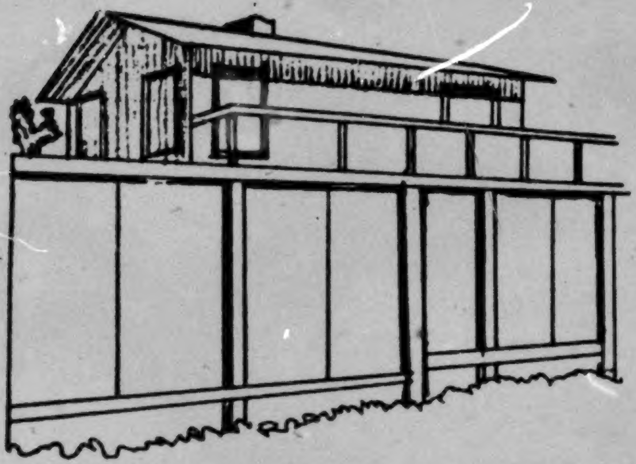

PP & L ENERGY CONSERVATION HOUSE

1.12

Building name: Dimatrodon Condiminium
Author: W. Maclay, R. Travers, J. Sanford
Date: 1975
Use of building: residence
Duration of operation:
Location: East Warren, Vermont
  Latitude: 44° N
  Altitude: 500 ft.
  Normal degree-days/year: 8269
  Ave. Jan. solar intensity on horizontal surface: 120 ly/Day
  Minimum design temperature: -15° F
  Ave. Jan. temperature: 15°
Building, floor area heated: ten contigous buildings
  Number of heated levels:
  Windows:
  Walls:
  Roof:
  Indoor design temperature:
  Design (max.) heat load:
  Ave. Jan. heat load:
  Btu required per degree day:
  Total winter demand:
Collector, type, heat transfer fluid: water heating; Thomason trickling water type
  Position, orientation, tilt above horizontal: south roofs, 60° slope
  Area: 2700 sq. ft. (gross) ; 2500 sq. ft. (net) ; (31 ft. x 88 ft.)
  Reflector, area and slope: none
  Type of heat transfer surface: corrugated galvanized iron sheets
  Glazing: double glazing of fiberglass reinforced polyester sheets
  Cost:
  Freeze protection: draining
Storage, type: water & stone
  Volume: 12,000 gallons
  Weight:
  Water equivalent:
  Container: 3 steel storage tanks (4000 gallons each) surrounded by 100 (?) tons of stone
  Heat capacity:
  Normal maximum temperature:
  Jan. storage in days:
Auxiliary energy supply, type: gas heaters, wood stoves, and wind generator
  Capacity:
  Mode of supply to system:
Heat collection and distribution:
  Transfer to storage: circulating water
  Motor requirement:
  Transfer to rooms:
  Motor requirement:
  Collector flow rate:
  House flow rate:
Hot water supply:
  Auxiliary heat:
  Solar source:
  Transfer means:
Automatic controls:
  Collector and storage thermostats:
  Automatic control of auxiliary:
  Automatic valves and dampers:
  Heating direct from collector:
  Automatic data recording:
  Pyroheliometer on site:
Cooling:
  Heat disposal method:
  Auxiliary cooling:
  Power required:
  Heat removal from rooms:
Performance:
  Period:
  Ave. collector efficiency while operating:
  Ave. collector efficiency, total radiation:
  Total winter heat supply by solar:
  Auxiliary energy supply:
  Heat equivalent of auxiliary:
  Percent load supplied by solar:
  Expected (theoretical) performance:

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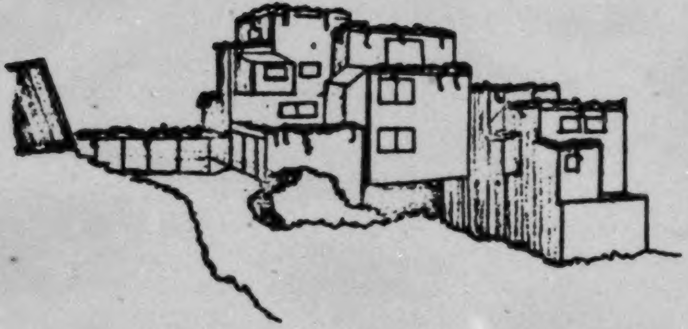

DIMETRODON CONDIMINIUM

1.13

Building name: Federal Office Building
Author: 69A/Dubin-Mindell-Bloome, engineers; Isaak & Isaak, architects
Date: To be occupied spring of 1976
Use of building: Federal offices for 418 people[a]
Duration of operation:
Location: Manchester, N.H.
Latitude: 43°N
Altitude: 170 ft.
Normal degree-days/year: 7600 (Concord)
Ave. Jan. solar intensity on horizontal surface: 130 ly/Day
Minimum design temperature: -15°F (Concord)
Ave. Jan. temperature: 20°F (Concord)
Building, floor area heated: 175,000 sqft. (gross); 131,000 sqft. (net) (40,000 sqft., site)
Number of heated levels: 7 floors, on top of 2 level parking podium
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Water heating
Position, orientation, tilt above horizontal: On roof, four rows, variable tilt 9° to 70°
Area: 5,000 sqft.; 6,000 sqft. (?)
Reflector, area and slope: None
Type of heat transfer surface:
Glazing:
Cost: Entire building cost $6,8000,000 (estimated)
Freeze protection: Antifreeze
Storage, type: Hot water
Volume: 30,000 gal.
Weight: 250,000 lb.
Water equivalent: Same
Container: Three tanks under building
Heat capacity: 16.2 million Btu[b]
Normal maximum temperature:
Jan. storage in days:
Auxiliary energy supply, type: Yes
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: Store hot water
Motor requirement:
Transfer to rooms: Low velocity, variable flow air system, with water loop heat pumper
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply: Yes
Auxiliary heat: Yes
Solar source: Preheat from roof collectors
Transfer means:
Automatic controls: Full
Collector and storage thermostats: Yes
Automatic control of auxiliary: Yes
Automatic valves and dampers: Yes
Heating direct from collector: No
Automatic data recording: Yes, National Bureau of Standards
Pyroheliometer on site:
Cooling: Yes (solar driven absorption chillers were considered and rejected)
Heat disposal method: Cooling tower
Auxiliary cooling: Yes
Power required:
Heat removal from rooms: Supply cool air
Performance:
Period: 1976 on
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance:

Other Comments:

[a]calculated by R. Gray, at $\Delta t=65^{\circ}F$.

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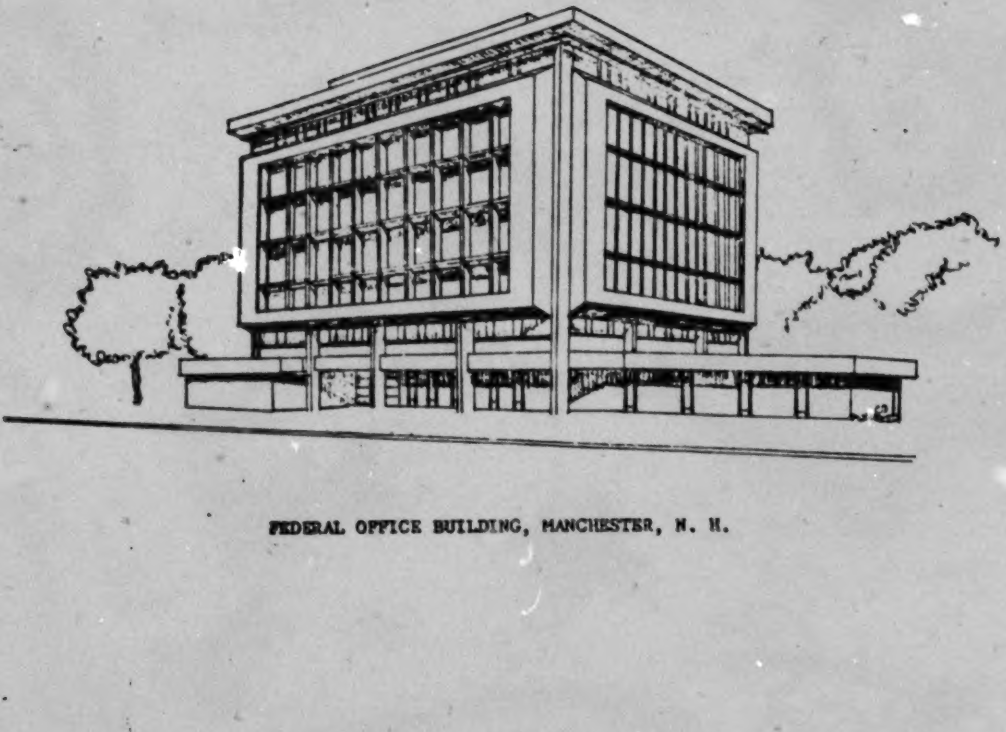

FEDERAL OFFICE BUILDING, MANCHESTER, N. H.

1.14

Building name: Audubon Society Offices
Author: A.D. Little Consultants, Cambridge, Mass.; Cambridge Seven, architects
Date: Proposed
Use of building: Offices
Duration of operation:
Location: Lincoln, Mass.
Latitude: 42°N
Altitude: Approx. 200 ft.
Normal degree-days/year: 5800
Ave. Jan. solar intensity on horizontal surface: 160 ly/day
Minimum design temperature: -10°F
Ave. Jan. temperature: 29°F
Building, floor area heated: 8,000 sqft.
Number of heated levels:
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Water heating
Position, orientation, tilt above horizontal: South roof, 45° slope
Area: 3,500 sqft.
Reflector, area and slope: None
Type of heat transfer surface: Aluminum tube in sheet
Glazing: Double glass
Cost:
Freeze protection:
Storage, type: Water
Volume: 7,500 gal.
Weight: 30 tons = 62,300 lb.(a)
Water equivalent: 7,500 gal.
Container: Tank
Heat capacity: 4.1 million Btu
Normal maximum temperature:
Jan. storage in days: 2 days
Auxiliary energy supply, type: Yes
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: Circulating water
Motor requirement: Water pump
Transfer to rooms:
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply: Yes
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling:
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 56% - 85% of heating load supplied by solar

Other comments:

[a] Calculated by R. Gray, at $\Delta t = 65°F$

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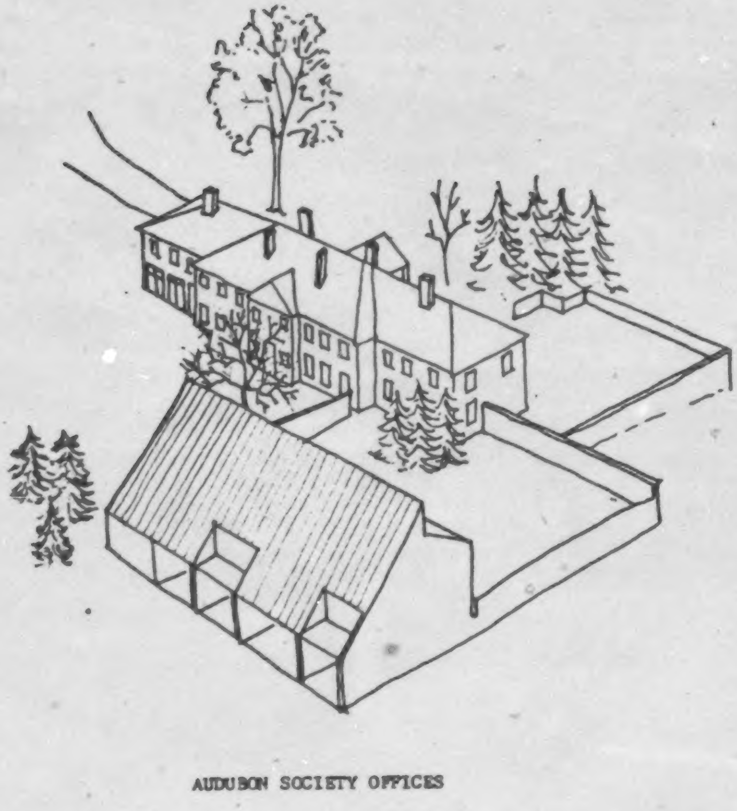
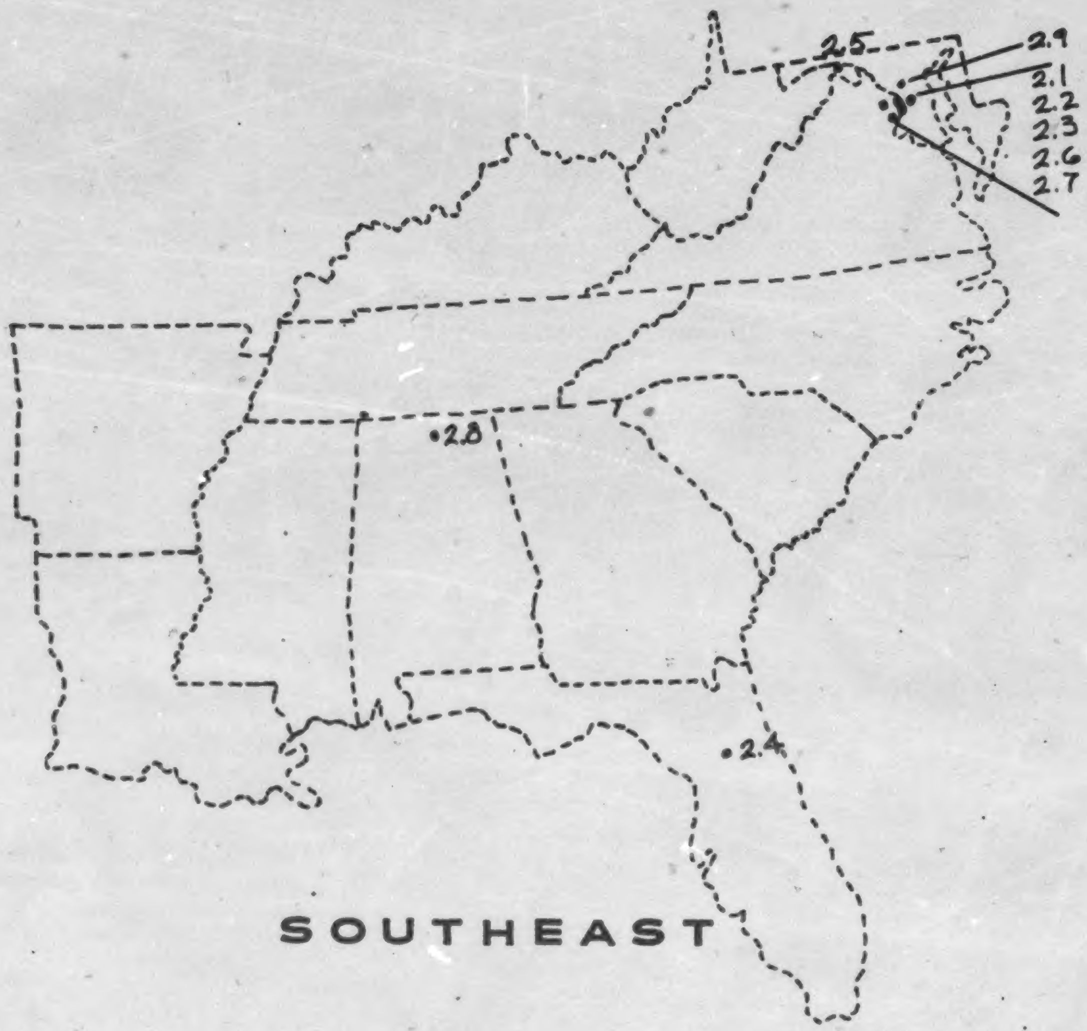


AUDUBON SOCIETY OFFICES


2.5
2.9
2.1
2.2
2.3
2.6
2.7
2.8
2.4
SOUTHEAST

2.1

Building name: "Solaris" House no. 1
Author: Harry Thomason
Date: Constructed in 1959
Use of building: Residence
Duration of operation: Still in use (14 years)
Location: Washington, D.C.
Latitude: 39°N
Altitude: Approx. 50 ft.
Normal degree-days/year: 4300
Ave. Jan. solar intensity on horizontal surface: 160 ly/day
Minimum design temperature: 13°F
Ave. Jan. temperature: 36°F
Building, floor area heated: 900 sqft.
Number of heated levels: One
Windows:
Walls:
Roof:
Indoor design temperature: 72°F
Design (max.) heat load: 17,208.4(a) BTU/H (e)
Ave. Jan. heat load: 8,400 Btuh.
Btu required per degree day: 7,000 Btu(a)
Total winter demand: 30,100,000 BTU (e)
Collector, type, heat transfer fluid: Water heating
Position, orientation, tilt above horizontal: 10° west of south; 60° wall (10' x 38') and 45° roof (12' x 38')
Area: 840 sqft.(b)
Reflector, area and slope: None
Type of heat transfer surface: Corrugated sheet metal
Glazing: One sheet 5 mil polyester and one sheet glass (3/4" air space)(c)
Cost: $2,500 for entire system
Freeze protection:
Storage, type: Water and rocks
Volume: 1,600 gal. water surrounded by 50 tons stone
Weight: 57 tons
Water equivalent:
Container: Bin, 10' x 25' x 7', tank 4' diameter x 17'
Heat capacity: 1.6 million Btu
Normal maximum temperature: 125°F - 135°F
Jan. storage in days: 5 days
Auxiliary energy supply, type: Yes, oil furnace
Capacity: Full load
Mode of supply to system: Heat house air bypassing storage
Heat collection and distribution:
Transfer to storage: Circulating hot water, conduct to rocks
Motor requirement: Water pump, 1/3 H.P.
Transfer to rooms: Air circulating through rocks
Motor requirement: Blower, 1/4 H.P.
Collector flow rate: 7.15 gal./min
House flow rate:
Hot water supply: Yes, preheat
Auxiliary heat: Electrical hot water heater
Solar source: Hot water from collector
Transfer means: One tank in another
Automatic controls: Partial
Collector and storage thermostats: Collector
Automatic control of auxiliary: Yes, by house thermostat
Automatic valves and dampers: One swing damper
Heating direct from collector: No
Automatic data recording: Partial
Pyroheliometer on site: No
Cooling: Yes
Heat disposal method: Night convection and evaporation
Auxiliary cooling: None
Power required: 1/4 H.P. blower and 1/3 H.P. water pump!
Heat removal from rooms: House air through cooled stone
Performance:
Period: 1960-1961 winter(d)
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply: 42 gal. fuel oil
Heat equivalent of auxiliary: 4-5 million Btu
Percent load supplied by solar: Estimated 95%(d)
Expected (theoretical) performance:

Other Comments:

(a) heat load estimated by Thomason

(b) When the collector was rebuilt after 5 years, it was reduced in size to about 800 sq. feet.

(c) the glazing was changed after three years to a single layer of glass, when the plastic failed.

(d) Thomason reports that over a 14 year period 65-95% of the heat was supplied by solar energy. The house area is 1500 sq. feet total.

(e) Calculated by Q. Bruhn

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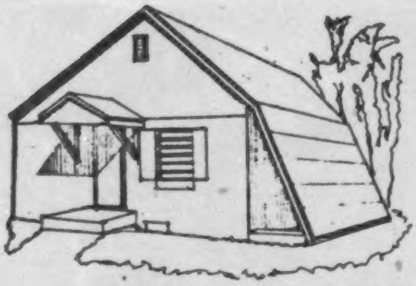

SOLARIS HOUSE #1

2.2

Building name: "Solaris" House no. 2
Author: Harry Thomason
Date: Constructed in 1960
Use of building: Residence
Duration of operation: Still in use
Location: Washington, D.C.
Latitude: 39°N
Altitude: Approx. 50 ft.
Normal degree-days/year: 4300
Ave. Jan. solar intensity on horizontal surface: 160 ly/day
Minimum design temperature: 13°F
Ave. Jan. temperature: 36°F
Building, floor area heated: 675 sqft.
Number of heated levels: One
Windows:
Walls:
Roof:
Indoor design temperature: 72°F
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Water heating
Position, orientation, tilt above horizontal: 10° west of sourth, 45° roof and 60° wall(a)
Area: 560 sqft.
Reflector, area and slope: 336 sqft. reflector, horizontal
Type of heat transfer surface: corrugated sheet metal
Glazing: One sheet glass
Cost: $2,000 for entire system
Freeze protection:
Storage, type: Water and rocks
Volume: 1600 gal. water surrounded by 60 tons of stone
Weight: 67 tons
Water equivalent:
Container: Bin and tank 4' diameter x 17'
Heat capacity: 1.7 million Btu(b)
Normal maximum temperature:
Jan. storage in days:
Auxiliary energy supply, type: Yes, electrical resistance
Capacity:
Mode of supply to system: Air heating
Heat collection and distribution:
Transfer to storage: Circulating hot water, conduct to rocks
Motor requirement: Water pump, 1/6 H.P.
Transfer to rooms: Air circulating through rocks
Motor requirement: Blower, 1/4 H.P.
Collector flow rate:
House flow rate:
Hot water supply: Yes, preheat
Auxiliary heat: Electric hot water heater
Solar source: Hot water from collector
Transfer means: One tank in another
Automatic controls: Partial
Collector and storage thermostats: Collector
Automatic control of auxiliary: Yes, by house thermostats
Automatic valves and dampers:
Heating direct from collector: No
Automatic data recording:
Pyroheliometer on site:
Cooling: Yes
Heat disposal method: Cold air blown through rocks; stored in rocks and water
Auxiliary cooling: Standard air-conditioning compressor (24,000 Btuh.)
Power required: 3/4 H.P. compressor and 1/4 H.P. blower
Heat removal from rooms: House air through cooled stone
Performance:
Period: Since construction
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar: 60-75%
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance:

Other Comments:

The air-conditioning is perated at night during off-peak hours chilling the rocks in the storage bin. The reflector increases the solar radiation by 15-30% by Thomason's estimate. The house area is 1000 sq. feet total.

(a) 55° roof and 65° wall.

(b) by comparison to Thomason's Solar House 1.

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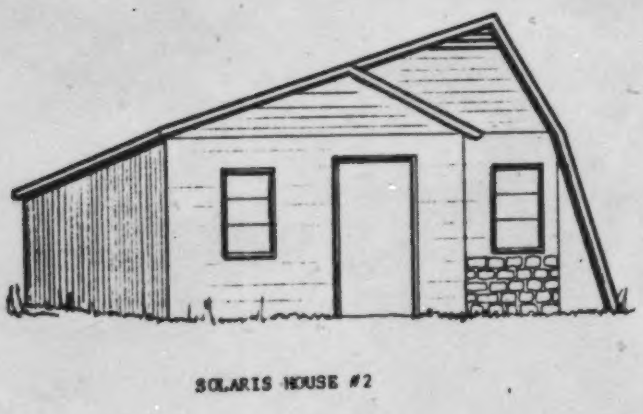

SOLARIS HOUSE #2

- Building name: "Solaris" House no. 3
- Author: Harry Thomason
- Date: Constructed in 1963
- Use of building: Residence
- Duration of operation: Still in use
- Location: Washington, D.C.
  - Latitude: 39°N
  - Altitude: Approx. 50 ft.
  - Normal degree-days/year: 4300
  - Ave. Jan. solar intensity on horizontal surface: 160 ly/day
  - Minimum design temperature: 13°F
  - Ave. Jan. temperature: 36°F
- Building, floor area heated: 1,500 sqft.
  - Number of heated levels: Two
  - Windows:
  - Walls:
  - Roof:
  - Indoor design temperature:
  - Design (max.) heat load:
  - Ave. Jan. heat load:
  - Btu required per degree day:
  - Total winter demand:
- Collector, type, heat transfer fluid: Water heating
  - Position, orientation, tilt above horizontal: 10° west of south, 60° slope
  - Area: 900 sqft.
  - Reflector, area and slope: 600 sqft. reflector at 7° slope (15' x 40'), non-metalic
  - Type of heat transfer surface: Corrugated sheet metal
  - Glazing: Single glass
  - Cost:
  - Freeze protection:
- Storage, type: Water and rocks
  - Volume: 3,000 gal. of water surrounded by 25 tons of stone[a]
  - Weight: 29 tons
  - Water equivalent:
  - Container: Bin, 9' x 30' x 7' and steel tank
  - Heat capacity: 2.0 million Btu[b]
  - Normal maximum temperature:
- Auxiliary energy supply, type: Yes, oil furance
  - Capacity: Full capacity
  - Mode of supply to system: Heat house air bypassing storage
- Heat collection and distribution: Circulating hot water, conduct to rocks
  - Transfer to storage:
  - Motor requirement: Water pump, 1/2 H.P.
  - Transfer to rooms: Air circulating through rocks
  - Motor requirement: Blower, 1/2 H.P.
  - Collector flow rate:
  - House flow rate:
- Hot water supply: Yes, preheat
  - Auxiliary heat: Electric hot water heater
  - Solar source: Hot water from collector
  - Transfer means: One tank in another
- Automatic controls: Yes
  - Collector and storage thermostats:
  - Automatic control of auxiliary: Yes, by house thermostat
  - Automatic valves and dampers: One damper
  - Heating direct from collector: No
  - Automatic data recording: Partial
  - Pyroheliometer on site:
- Cooling: Yes
  - Heat disposal method: Cold air blown through rocks, stored in rocks and water
  - Auxiliary cooling: Standard air-conditioning compressor (34,000 Btuh.)
  - Power required: 1/2 H.P. blower and compressor
  - Heat removal from rooms: House air through cooled stone
- Performance:
  - Period: Since construction
  - Ave. collector efficiency while operating:
  - Ave. collector efficiency, total radiation:
  - Total winter heat supply by solar: 60-70%
  - Auxiliary energy supply:
  - Heat equivalent of auxiliary:
  - Percent load supplied by solar: 85% in mild winter, 75% typical winter
  - Expected (theoretical) performance:

Other Comments:

House also includes 6000-7000 gallon swimming pool solar heated during spring and fall. House area is 3400 square feet total.

[a] 2500 gallon tank, 45" x 45" x 25"; 2/3 filled to 1600 gallons water, 25 tons of stone in bin 10' x 7' x 30' (5).

[b] by comparison to Thomason's Solar House I.

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Thomason, Harry and Jack, Solar House Plans, Edmund Scientific Co., Barrington, New Jersey, 1972.

------, Solar House Heating and Air-Conditioning, Edmund Scientific Co., Barrington, New Jersey, 1974.

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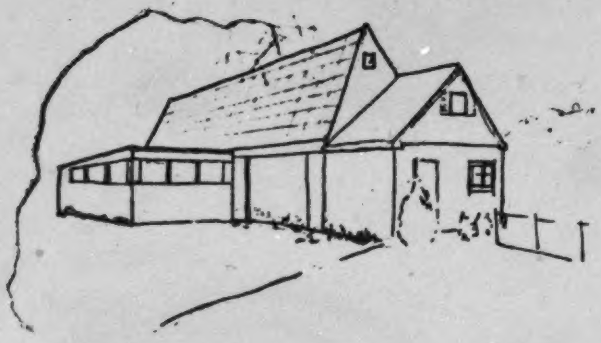

SOLARIS HOUSE #3

2.4

Building name:
Author: Farber
Date: Built in 1955, partial solar heat 1963, full solar heat 1973, solar cooling 1974
Use of building: Residence
Duration of operation: 1963-present
Location: Gainesville, Florida off campus, University of Florida
Latitude: 29.5° N
Altitude: 150 ft.
Normal degree-days/year: 1113 (Jacksonville)
Ave. Jan. solar intensity on horizontal surface: 265 ly/day
Minimum design temperature: 25° F
Ave. Jan. temperature: 55° F (Jacksonville)
Building, floor area heated: 770 sq. ft. (24 ft. x 36 ft.)
Number of heated levels: one
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Water
Position, orientation, tilt above horizontal:12 panels on roof, facing south, about 40° tilt)
Area: 10 x (4' x 8') panels = 360 sqft. (guess from photo, R. G.)
Reflector, area and slope: none
Type of heat transfer surface: rectangular copper tubes, (4-6 in. centers), clamped to copper
Glazing: single glass layer (low iron content)
Cost:
Freeze protection:
Storage, type: Water
Volume: 3,000 gallons
Weight: 25,000 lb.
Water equivalent:
Container: 5 ft. diameter, 19 ft. long lined steel tank with glass foam
Heat capacity: 1.6 milltion Btu[a]
Normal maximum temperature: 130° F, 120° F hold on a "cold, rainy winter day"[b]
Jan. storage in days:
Auxiliary energy supply, type: furnace; oil or natural gas
Capacity: full
Mode of supply to system: convectors (hot water) or forced air
Heat collection and distribution:
Transfer to storage: circulating water
Motor requirement:
Transfer to rooms: Baseboard fin-tube convectors, meet design conditions w/130° F water)
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply: Yes, thermosyphon solar water heater
Auxiliary heat: none
Solar source: Separate collector (13th on roof), same as others (48sq. ft.)
Transfer means: Domestic water flows through collector to storage tank on roof by convection
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling: since 1974 (new collector of 500 sq. ft., 30° slope
Heat disposal method: solar powered intermittently-operated ammonia-water absorption a/c
Auxiliary cooling: none
Power required:
Heat removal from rooms:
Performance:
Period: 1963-1972
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply: none
Heat equivalent of auxiliary:
Percent load supplied by solar: 100 % of heating
Expected (theoretical) performance:

Other comments:

Also a solar still in the backyard recovers water from kitchen and bath waste.

Also 8 panels about 3' x 8', 45° tilt, in the yard heat the swimming pool.

(a) Calculated by R. Gray, $\Delta t = 65°F$

(b) see Gilmore

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Farber, talk at NSF/ASHRAE Workshop on Solar Cooling of Buildings, L. A., February, 1974

Gilmore, "Can Sunshine Heat (and Cool) Your House?", Popular Science, March, 1974, page 81.

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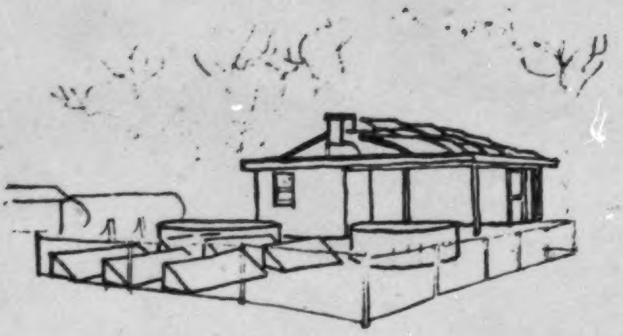

FARBER RESIDENCE

2.5

- **Building name:** Mrs. A.N. Wilson Residence
- **Author:** Bunt, Hill Associates; P.R. Rittelmann, project architect
- **Date:** Construction to begin Fall 1973; postponed due to financing
- **Use of building:** Residence
- **Duration of operation:**
- **Location:** Shanghai, West Virginia (Martinsburg, 60 miles northwest of Washington, D.C.)
  - **Latitude:** 39°N
  - **Altitude:** Approx. 540 ft.
  - **Normal degree-days/year:** 4928
  - **Ave. Jan. solar intensity on horizontal surface:** 150 ly/Day
  - **Minimum design temperature:** 0°
  - **Ave. Jan. temperature:** 32°F
- **Building, floor area heated:** 1,400 sqft.
  - **Number of heated levels:** 2-1/2
  - **Windows:** 312 sq ft. R=4.3
  - **Walls:** 566 sq ft. R=16.9
  - **Roof:** 1255 sq ft. R=20.7
  - **Indoor design temperature:** 68°
  - **Design (max.) heat load:** 35,037 BTU/H
  - **Ave. Jan. heat load:** 12,743,006 BTU
  - **Btu required per degree day:** 12,366 BTU
  - **Total winter demand:** 70,100,808 BTU
- **Collector, type, heat transfer fluid:** Water heating
  - **Position, orientation, tilt above horizontal:** South roof, 45° slope
  - **Area:** 600 sqft.
  - **Reflector, area and slope:** None
  - **Type of heat transfer surface:** 40 mil aluminum with 1/4" aluminum tubes 6" o.c.
  - **Glazing:** Single glass over two layers mylar
  - **Cost:**
  - **Freeze protection:** Ethylene glycol
- **Storage, type:** Water
  - **Volume:** 2,400 gal. of water main tank, 400 gal. supplementary tank
  - **Weight:** 23,400 lb.
  - **Water equivalent:**
  - **Container:** Concrete tank with liner and polyurethane board insulation
  - **Heat capacity:** 1.5 million Btu.[(a)]
  - **Normal maximum temperature:** 130° large tank 150° small tank
  - **Jan. storage in days:** 51 hours at 33° outside Temp. 30 hours at 0° outside Temp.
- **Auxiliary energy supply, type:** Yes, oil furnace
  - **Capacity:** 84,000 BTU/H
  - **Mode of supply to system:** Supplied to 400 gal. water storage tank
- **Heat collection and distribution:**
  - **Transfer to storage:** Circulating water-glycol solution
  - **Motor requirement:** Circulating pump
  - **Transfer to rooms:** From coil to house air with variable velocity depending on water temperature
  - **Motor requirement:** Water pump and blower
  - **Collector flow rate:**
  - **House flow rate:** 680 - 1600 CFM
- **Hot water supply:** Yes
  - **Auxiliary heat:** oil
  - **Solar source:** yes
  - **Transfer means:** coil
- **Automatic controls:**
  - **Collector and storage thermostats:** set at 5° differential Temp.
  - **Automatic control of auxiliary:** yes
  - **Automatic valves and dampers:** yes
  - **Heating direct from collector:** no, first into storage tank
  - **Automatic data recording:** no
  - **Pyroheliometer on site:** no
- **Cooling:** Yes Absorption unit
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:**
  - **Period:**
  - **Ave. collector efficiency while operating:** assumed 35%
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:**
  - **Auxiliary energy supply:** 10%
  - **Heat equivalent of auxiliary:** 7,606,475 BTU
  - **Percent load supplied by solar:** 90%
  - **Expected (theoretical) performance:** 81% of heating and electrical load

Comments

Other Comments

(a.) Calculated by R. Gray at $\Delta t = 65^{\circ}$F.

(b.) 12 days storage; also, storage looses 1°F per day at 150°F

(c.) P.O. Box 340, Warrenton, VA 22186

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Washington Post, 2/2/74.

Shurcliff, William, "Solar-Heated Buildings: A Brief Survey", 1974, p.60.

Building name: Fanquier County High School
Author: Intertechnology Corporation, Warrenton, Va.
Date: March, 1974
Use of building: Five mobile high school classrooms, 150 students
Duration of operation: Test March 1974 - June 1975
Location: Warrenton, Virginia
Latitude: 39°N
Altitude: Approx. 500 ft.
Normal degree-days/year: 4300 (Washington, D.C.)
Ave. Jan. solar intensity on horizontal surface: 160 ly/day (Thomasson)
Minimum design temperature: 13°F (Washington, D.C.)
Ave. Jan. temperature: 36°F (Washington, D.C.)
Building, floor area heated: 4,500 sqft., in five separate buildings
Number of heated levels: One
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Water heating
Position, orientation, tilt above horizontal: 53° tilt, free standing on scaffolding
Area: 2,500 sqft. (overall 126' x 26')
Reflector, area and slope:
Type of heat transfer surface: Roll-Bond aluminum panels from Olin Brass Co., 105 panels of 3-1/2' x 8'
Glazing: Multiple layers of glass and plastic
Cost: NSF grant of $173,000
Freeze protection: Drains in 80 seconds, water-glycol solution in collector
Storage, type: Store heated water
Volume: 12,000 gal.
Weight: 1,000,000 lb.
Water equivalent:
Container: Two heavily insulated tanks underground
Heat capacity: 5.2 million Btu
Normal maximum temperature:
Jan. storage in days: 5 days storage
Auxiliary energy supply, type: Existing conventional system
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage:
Motor requirement:
Transfer to rooms:
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls: Automatically selects one of eleven possible modes of operation
Collector and storage thermostats:
Automatic control of auxiliary: Auxiliary room thermostat is set 2°F below solar room thermostat
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling: Absorption solar driven air conditioning may be installed this summer
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation: 53% to 63%
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar: 100% of need of five buildings
Expected (theoretical) performance:

Other comments:

The architect is P. Richard Rittelman of Burt, Hill & Associates, Pittsburgh, Pa. NSF, Comsat and other industries are contributing to the demonstration project. Silicon photorotaic cells on garage supplied by Comsat; wind genurator and electric storage batteries (3 day storage capacity). House includes a two story greenhouse (glass box) on side of house; opening at bottom to let in air which is circulated through the house. Residence will also utilized "clivus" aerobic waste digestion system.

(a) Calculated by R. Gray, at $\Delta t = 65^{o}F$.

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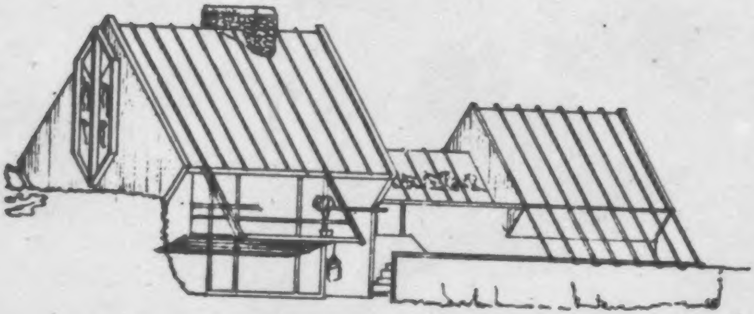

MRS. A. N. WILSON RESIDENCE

2.7

- Building name: Madeire School, New Science Wing
- Author: Arthur Cotton Moore, architect; Flack & Kurty, engineers
- Date: 1974-75
- Use of building: Science laboratories of school
- Duration of operation:
- Location: McLean, Virginia
    - Latitude: 39°N
    - Altitude: Approx. 200 ft.
    - Normal degree-days/year: 4300 (Washington, D.C.)
    - Ave. Jan. solar intensity on horizontal surface: Approx. 160 ly/day (Thomason)
    - Minimum design temperature: 13°F (Washington, D.C.)
    - Ave. Jan. temperature: 36°F (Washington, D.C.)
- Building, floor area heated: 7,000 sqft. ($400,000 total including furnishings)
    - Number of heated levels:
    - Windows:
    - Walls:
    - Roof:
    - Indoor design temperature:
    - Design (max.) heat load:
    - Ave. Jan. heat load:
    - Btu required per degree day:
    - Total winter demand:
- Collector, type, heat transfer fluid: Water heating
    - Position, orientation, tilt above horizontal:
    - Area:
    - Reflector, area and slope:
    - Type of heat transfer surface: Metal tubes and plate
    - Glazing: Single glass
    - Cost: $26,000 for additional solar costs
    - Freeze protection:
- Storage, type: Hot water tank
    - Volume:
    - Weight:
    - Water equivalent:
    - Container:
    - Heat capacity:
    - Normal maximum temperature:
    - Jan. storage in days:
- Auxiliary energy supply, type:
    - Capacity:
    - Mode of supply to system:
- Heat collection and distribution:
    - Transfer to storage: Pump from collector to storage
    - Motor requirement:
    - Transfer to rooms:
    - Motor requirement:
    - Collector flow rate:
    - House flow rate:
- Hot water supply:
    - Auxiliary heat:
    - Solar source:
    - Transfer means:
- Automatic controls:
    - Collector and storage thermostats:
    - Automatic control of auxiliary:
    - Automatic valves and dampers:
    - Heating direct from collector:
    - Automatic data recording:
    - Pyroheliometer on site:
- Cooling:
    - Heat disposal method:
    - Auxiliary cooling:
    - Power required: Solar driven absorption cooling
    - Heat removal from rooms: Conventional air handling unit
- Performance:
    - Period:
    - Ave. collector efficiency while operating:
    - Ave. collector efficiency, total radiation:
    - Total winter heat supply by solar:
    - Auxiliary energy supply:
    - Heat equivalent of auxiliary:
    - Percent load supplied by solar:
    - Expected (theoretical) performance: Same $1,500/year on fuel at 1974 prices

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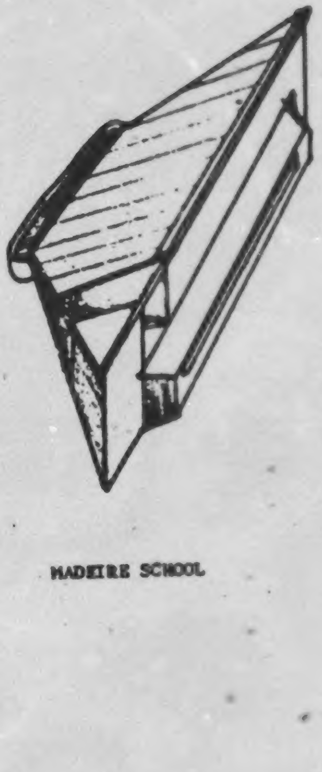

MADEIRE SCHOOL

2.8

Building name: NASA Solar House
Author: NASA/Lockheed
Date: 1974 or 1975
Use of building: lab
Duration of operation:
Location: Huntsville, Alabama
  Latitude: 35° N
  Altitude: 600 ft
  Normal degree-days/year: 2780 (Birmingham)
  Ave. Jan. solar intensity on horizontal surface: 848 BEU/SF/Day
  Minimum design temperature: + 10° F
  Ave. Jan. temperature: 45°
Building, floor area heated: 1520 sq. ft., three trailers joined together (b)
  Number of heated levels: one
  Windows:
  Walls: 72,000 BtuH
  Roof:
  Indoor design temperature:
  Design (max.) heat load:
  Ave. Jan. heat load:
  Btu required per degree day:
  Total winter demand:
Collector, type, heat transfer fluid: water
  Position, orientation, tilt above horizontal: on south roof, 45° tilt
  Area: 1300 sq. ft.
  Reflector, area and slope: none
  Type of heat transfer surface: Alu. expanded tube, 60 mil.,W/NASA selective black nickel surface
  Glazing: One layers 0.004 tedlar with wire reinforcing (Du Pont polyvinyl flouride)
  Cost: at $1.00/sq. ft. collector (production) $3400 for system.
  Freeze protection:
Storage, type: water
  Volume: 3600 gal.
  Weight: 30,100 lb. (a)
  Water equivalent: same
  Container: 4700 gal. horizontal cylindrical aluminum tank, 2-3 ft. of $3\text{-lb.}/\text{ft}^3$ fiberglass
  Heat capacity: 2,400,000 BEU at 80° F at (a)
  Normal maximum temperature: 260°F
  Jan. storage in days:
Auxiliary energy supply, type: gas furnace
  Capacity:
  Mode of supply to system: fan coil
Heat collection and distribution:
  Transfer to storage: pressurized water with sodium chromate (anti corrosion treatment)
  Motor requirement:
  Transfer to rooms: air
  Motor requirement:
  Collector flow rate: from main storage, 4,000 Btu/hr., 32×10^6 Bto/year, (antcipated)
  House flow rate:
Hot water supply: yes
  Auxiliary heat:
  Solar source:
  Transfer means: heating coil in storage
Automatic controls: yes
  Collector and storage thermostats: yes
  Automatic control of auxiliary: yes
  Automatic valves and dampers: yes
  Heating direct from collector:
  Automatic data recording: yes
  Pyroheliometer on site: yes
Cooling: yes
  Heat disposal method: modified "Arkla" Lithium bromide absorption air conditioner
  Auxiliary cooling: Natural gas drives absorption air conditioner
  Power required: 3-ton unit
  Heat removal from rooms: forced air
Performance:
  Period:
  Ave. collector efficiency while operating:
  Ave. collector efficiency, total radiation:
  Total winter heat supply by solar:
  Auxiliary energy supply:
  Heat equivalent of auxiliary:
  Percent load supplied by solar:
  Expected (theoretical) performance: 93% of heating ; expected collector efficiency (total radiation) 50%-60% ; 112×10^6 Btu/year (winter heat supply) and 34×10^6 Btu/year domestic hot water

Other Comments:

All these values are anticipated performance.

(a) calculated by R. Gray

(b) trailers are 58 ft.x10 ft., 58 ftx10 ft., 30 ft.x12ft., and and in a long E-W line.

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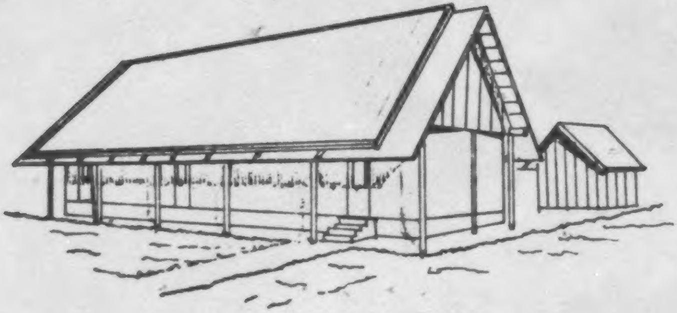

NASA SOLAR HOUSE

2.9

Building name: Timonium Elementary School
Author: Aircraft Armaments, Inc. (NSF grant)
Date: March, 1974
Use of building: Elementary school, experiment on one wing of school
Duration of operation: Experiment 1974-1975
Location: Timonium, Maryland
Latitude: 39°N (Baltimore)
Altitude: 500 ft
Normal degree-days/year: 4500 (Baltimore)
Ave. Jan. solar intensity on horizontal surface: Approx. 160 ly/day (Thomasson)
Minimum design temperature: 0°F (Baltimore)
Ave. Jan. temperature: Approx. 35°F
Building, floor area heated: 10,200 sqft. (eight classrooms)
Number of heated levels: One
Windows:
Walls:
Roof:
Indoor design temperature: 68°F daytime, 60°F nighttime
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Water heating
Position, orientation, tilt above horizontal: On roof, 45° tilt, facing south(b)
Area: 5,700 sqft., 10 rows 8 ft. high by 76 ft. long, 10 feet between rows
Reflector, area and slope: None
Type of heat transfer surface: Aluminum panel with integral tubes, 4' x 8' panels
Glazing: With honeycomb
Cost: NSF $427,000, AAF $73,000
Freeze protection: Drain collector
Storage, type: Hot water
Volume: 15,000 gal.
Weight: 125,000 lb.
Water equivalent: Same
Container: Tank, heavily insulated, above ground, external to building
Heat capacity: 8.1 million Btu(c)
Normal maximum temperature:
Jan. storage in days: 4 to 5 days, estimated by AAI
Auxiliary energy supply, type: Yes, oil boiler
Capacity: Full
Mode of supply to system: Steam radiators
Heat collection and distribution:
Transfer to storage: Store hot water
Motor requirement:
Transfer to rooms: Hot water convectors along window walls, separate from backup
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls: Full
Collector and storage thermostats: Storage and collector,(a) room thermostats
Automatic control of auxiliary: Yes
Automatic valves and dampers:
Heating direct from collector: No
Automatic data recording: Full
Pyroheliometer on site:
Cooling:
Heat disposal method: (Experiments may be conducted summer, 1974)
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance:

Other comments:

(a) Solar sensor turns collector pump on or off, after being off for a time, collector drains to storage.

(b) Collector is supported by independent steel structure which rests on I-beams at east and west side of school, no additional loads are placed on the existing roof. The collector overhangs the roof by four feet, has six foot side walls which were not built in a recent photo, and an eight foot fence separating it from the rest of the roof, all to prevent vandalism. The pumps are in a prefab building next to the tank. The control panel is in a classroom.

(c) Calculated by R. Gray, $\Delta t = 65°F$.

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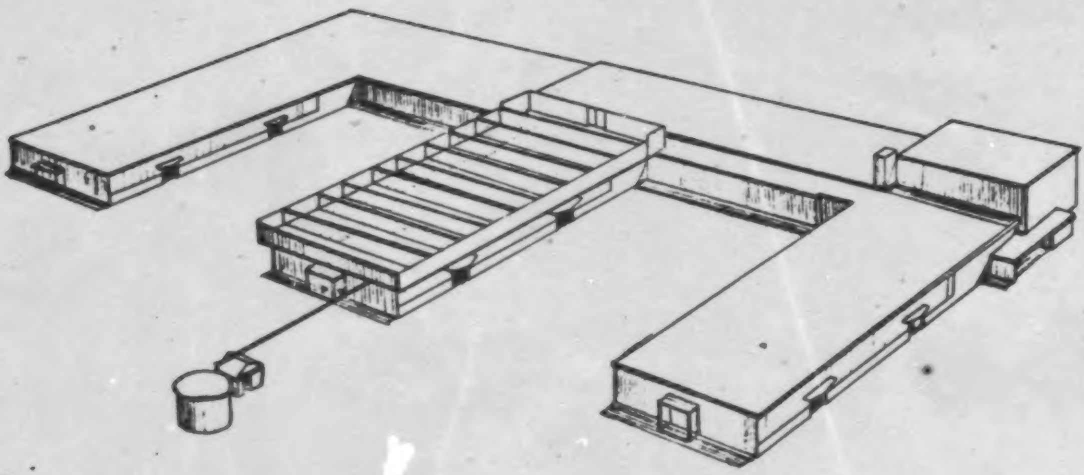
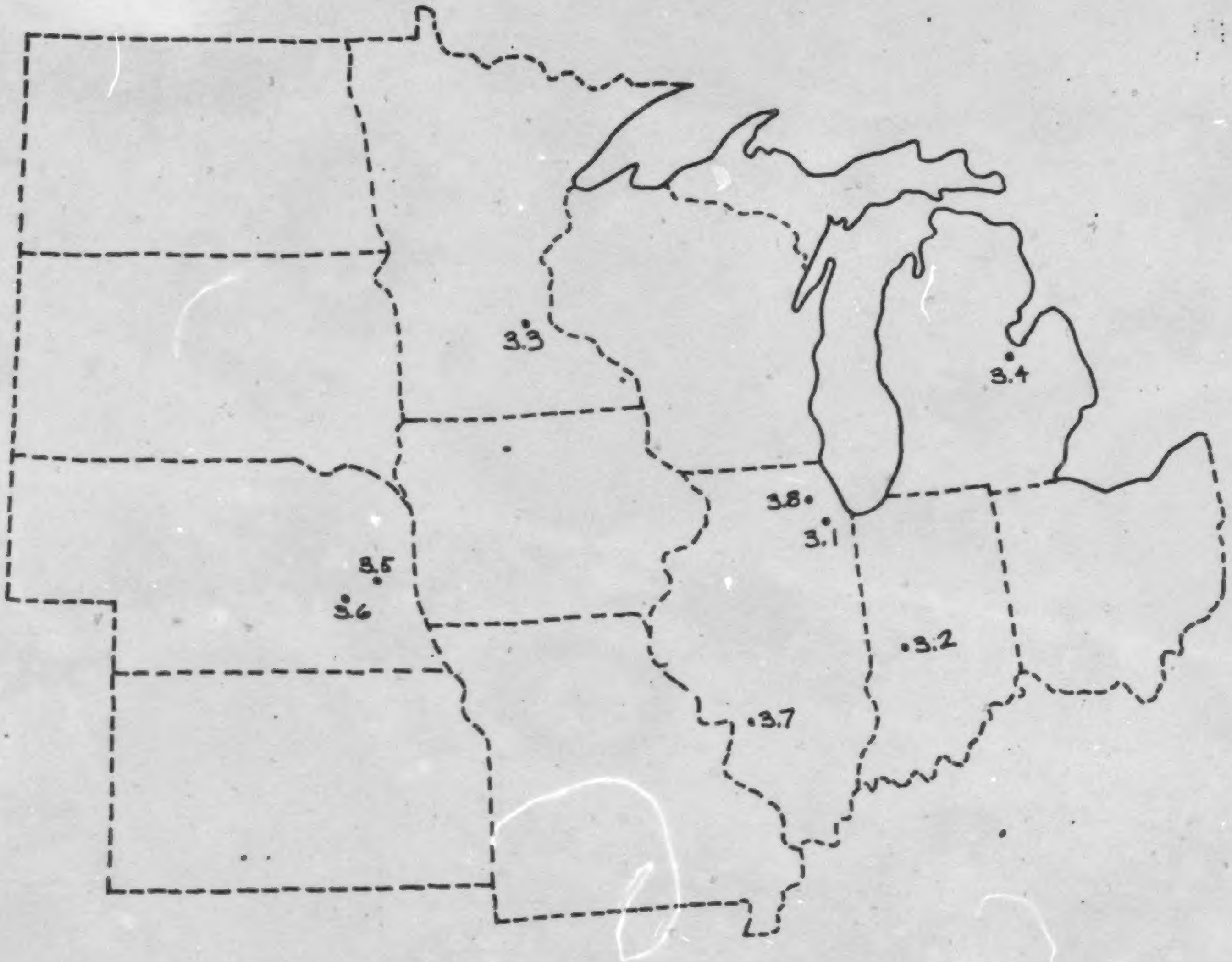


TIMONIUM ELEMENTARY SCHOOL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MIDWEST

3.1

- Building name: Keck Solar House
- Author: George Fred Keck, architect and developer
- Date: 1941
- Use of building: Residence
- Duration of operation: Data recorded October, 1941 to October, 1942
- Location: Near Chicago
    - Latitude: 42°N (Chicago)
    - Altitude: Approx. 600 ft. (Chicago)
    - Normal degree-days/year: 6280 (Chicago)
    - Ave. Jan. solar intensity on horizontal surface: 150 ly/Day
    - Minimum design temperature: -10°F
    - Ave. Jan. temperature: 25°F
- Building, floor area heated: 1,562 sqft.
    - Number of heated levels: One
    - Windows:
    - Walls:
    - Roof:
    - Indoor design temperature: 72°F
    - Design (max.) heat load:
    - Ave. Jan. heat load:
    - Btu required per degree day:
    - Total winter demand:
- Collector, type, heat transfer fluid: None, except south facing windows
    - Position, orientation, tilt above horizontal:
    - Area:
    - Reflector, area and slope:
    - Type of heat transfer surface:
    - Glazing:
    - Cost:
    - Freeze protection:
- Storage, type: None
    - Volume:
    - Weight:
    - Water equivalent:
    - Container:
    - Heat capacity:
    - Normal maximum temperature:
    - Jan. storage in days:
- Auxiliary energy supply, type: Yes, gas hot water furnace
    - Capacity: Full
    - Mode of supply to system: Hot water radiant piping in floor slab (1/6 H.P. pump)
- Heat collection and distribution:
    - Transfer to storage:
    - Motor requirement:
    - Transfer to rooms:
    - Motor requirement:
    - Collector flow rate:
    - House flow rate:
- Hot water supply: Gas fired domestic water heater
    - Auxiliary heat:
    - Solar source:
    - Transfer means:
- Automatic controls:
    - Collector and storage thermostats:
    - Automatic control of auxiliary: Room and outdoor thermometer control furnace
    - Automatic valves and dampers:
    - Heating direct from collector:
    - Automatic data recording: October, 1941 to October, 1942
    - Pyroheliometer on site: None
- Cooling: None
    - Heat disposal method:
    - Auxiliary cooling:
    - Power required:
    - Heat removal from rooms:
- Performance:
    - Period: October, 1941 to October, 1942
    - Ave. collector efficiency while operating:
    - Ave. collector efficiency, total radiation:
    - Total winter heat supply by solar: 330 therms, estimated
    - Auxiliary energy supply: 1,722 therms
    - Heat equivalent of auxiliary:
    - Percent load supplied by solar: 18%
    - Expected (theoretical) performance:

Other comments:

This is one of a number of solar "window" houses which architect and developer George Keck built around Chicago. There are 326 sqft. of glass on the south wall, which equals about 75% of the south wall, 27% of all exterior walls, and 21% of the floor area. The windows are double glazed with L.O.F. metal frame double glazing. The house is wood framed insulated with fibrous blankets and an aluminum foil faced air space. The roof is flat pitched with an overhang on the south for summer shading.

In 1941 and 1942 an engineering study was made of this house by J.C. Peebles and W.C. Knopf of the Illinois Institute of Technology, which was financed by Libby-Owen-Ford. Various temperatures and fuel consumption were recorder, but the results were inconclusive due to high levels of infiltration. The site is unusually windy, the new lumber shrunk and large cracks opened around the windows. Furthermore, the radiant heating in the slab (600 cuft. of concrete) was slow to respond to changes in solar radiation due to clouds, even though the furnace was controlled by both a room thermostat and a thermostat outside the south window. Placing an upside down milk bottle over the outside thermostat made it more sensitive to sunlight and less sensitive to wind; but the real problem was that the radiant floor heated the house, and any sudden increases in sunlight overheated the house causing the occupants to open windows to cool off the house. Thus the estimated 9.33 million Btu supplied by solar was calculated from U.S. Weather Bureau data on solar radiation, and not on the difference between calculated heat demand and actual fuel consumption.

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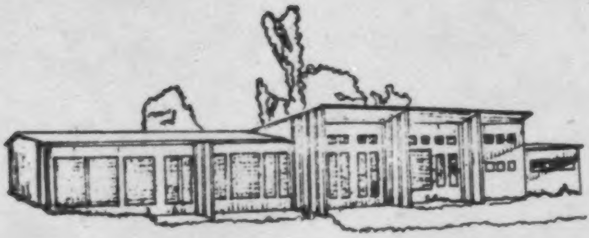

KECK SOLAR HOUSE

3.2

- **Building name:** Purdue Solar House
- **Author:** Professor F.W. Hutchinson
- **Date:** 1946
- **Use of building:** Laboratory
- **Duration of operation:**
- **Location:** Lafayette, Indiana
    - **Latitude:** 40°N
    - **Altitude:** Approx. 700 ft.
    - **Normal degree-days/year:** 5460 (Indianapolis)
    - **Ave. Jan. solar intensity on horizontal surface:** 150 ly/Day
    - **Minimum design temperature:** -10°F
    - **Ave. Jan. temperature:** 30°
- **Building, floor area heated:**
    - **Number of heated levels:**
    - **Windows:**
    - **Walls:**
    - **Roof:**
    - **Indoor design temperature:**
    - **Design (max.) heat load:**
    - **Ave. Jan. heat load:**
    - **Btu required per degree day:**
    - **Total winter demand:**
- **Collector, type, heat transfer fluid:**
    - **Position, orientation, tilt above horizontal:**
    - **Area:**
    - **Reflector, area and slope:**
    - **Type of heat transfer surface:**
    - **Glazing:**
    - **Cost:**
    - **Freeze protection:**
- **Storage, type:**
    - **Volume:**
    - **Weight:**
    - **Water equivalent:**
    - **Container:**
    - **Heat capacity:**
    - **Normal maximum temperature:**
    - **Jan. storage in days:**
- **Auxiliary energy supply, type:**
    - **Capacity:**
    - **Mode of supply to system:**
- **Heat collection and distribution:**
    - **Transfer to storage:**
    - **Motor requirement:**
    - **Transfer to rooms:**
    - **Motor requirement:**
    - **Collector flow rate:**
    - **House flow rate:**
- **Hot water supply:**
    - **Auxiliary heat:**
    - **Solar source:**
    - **Transfer means:**
- **Automatic controls:**
    - **Collector and storage thermostats:**
    - **Automatic control of auxiliary:**
    - **Automatic valves and dampers:**
    - **Heating direct from collector:**
    - **Automatic data recording:**
    - **Pyroheliometer on site:**
- **Cooling:**
    - **Heat disposal method:**
    - **Auxiliary cooling:**
    - **Power required:**
    - **Heat removal from rooms:**
- **Performance:**
    - **Period:**
    - **Ave. collector efficiency while operating:**
    - **Ave. collector efficiency, total radiation:**
    - **Total winter heat supply by solar:**
    - **Auxiliary energy supply:**
    - **Heat equivalent of auxiliary:**
    - **Percent load supplied by solar:**
    - **Expected (theoretical) performance:**

Other comments:

Two full scale identical test houses were built side by side, the only difference being that one was a solar "window" house with two-thirds of the south wall glass. The houses were heated electrically and consumption was compared.

The result was that the sunlight on a cold clear January day would overheat the solar house and windows had to be opened to cool the house. This result, which agreed with experience from other solar "window" houses (see Keck Solar House), indicated that some method of heat storage was needed to take advantage of strong but intermittent winter solar radiation.

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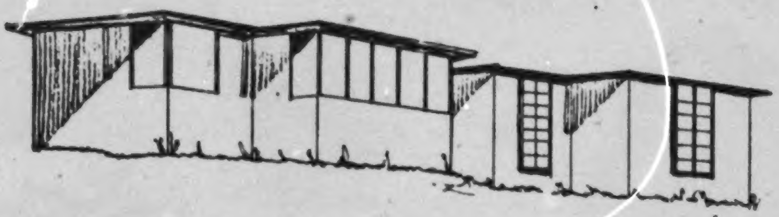

PURDUE SOLAR HOUSE

Building name: "Ouroboros" - South House
Author: Department of Architecture, University of Minnesota; Holloway, Hickman **3.3**
Date: Constructed in spring, 1973, solar system, March, 1974
Use of building: Residence
Duration of operation:
Location: Rosemount, Minnesota
    Latitude: 46°N
    Altitude: Approx. 1,000 ft.
    Normal degree-days/year: 7,800
    Ave. Jan. solar intensity on horizontal surface: 118 ly/day
    Minimum design temperature: -25°F
    Ave. Jan. temperature: 15°F
Building, floor area heated: 1,450 sqft. (w.s. 2,000 sqft.)
    Number of heated levels: 1-1/2
    Windows:
    Walls:
    Roof:
    Indoor design temperature: 68°F
    Design (max.) heat load:
    Ave. Jan. heat load:
    Btu required per degree day:
    Total winter demand:
Collector, type, heat transfer fluid: Water heating, Thomason type
    Position, orientation, tilt above horizontal: South; 60° roof
    Area: 728 sqft. (14' x 52')
    Reflector, area and slope: None
    Type of heat transfer surface: Corrugated sheet metal
    Glazing:
    Cost:
    Freeze protection:
Storage, type: Water, stone
    Volume: 2,000 gal. water, 50 (?) tons stone
    Weight: 16,700 lb. water, 50 (?) tons stone
    Water equivalent:
    Container:
    Heat capacity: 1.6 million Btu$^{(a)}$
    Normal maximum temperature:
    Jan. storage in days:
Auxiliary energy supply, type: None
    Capacity:
    Mode of supply to system:
Heat collection and distribution:
    Transfer to storage: Circulate hot water
    Motor requirement: 2-blade, 15' dia. wind generator powers pump
    Transfer to rooms:
    Motor requirement:
    Collector flow rate:
    House flow rate:
Hot water supply: Yes
    Auxiliary heat: None
    Solar source: Hot water from collector
    Transfer means:
Automatic controls:
    Collector and storage thermostats:
    Automatic control of auxiliary:
    Automatic valves and dampers:
    Heating direct from collector:
    Automatic data recording: Installed June, 1974
    Pyroheliometer on site:
Cooling: None
    Heat disposal method:
    Auxiliary cooling:
    Power required:
    Heat removal from rooms:
Performance:
    Period:
    Ave. collector efficiency while operating:
    Ave. collector efficiency, total radiation:
    Total winter heat supply by solar:
    Auxiliary energy supply:
    Heat equivalent of auxiliary:
    Percent load supplied by solar:
    Expected (theoretical) performance:

Other Comments:

Other features of the house include trapezoidal building shape to minimize heat loss while maximizing south exposure for solar windows and collectors, earth berms to take advantage of constant heat heat within the ground, avoidance of air-conditioning through design of ventilation insulation systems, a 4 KW wind electrical generator, insulation of all surfaces to 0.03 U-value, windows to be covered with insulating panels at night, double-glazed windows. House also includes "clivus" aerobic waste disposal system and Japanese mist shower to decrease water consumption. Trapezoid is 48ft. (S), 16 ft. (N), 32 ft, (E and W). Small greenhouse at southeast corner. Roof 9½" fiberglass insulation.

(a) by comparison to Thomason.

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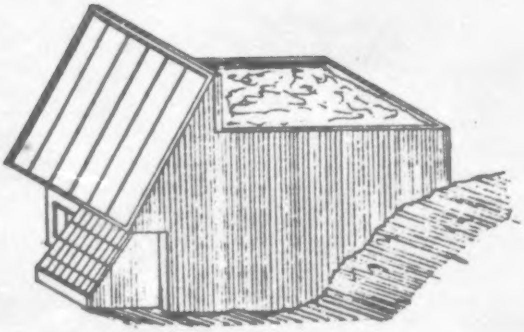

"OUROBOROS" - SOUTH HOUSE

3.4

Building name: Federal Building, Saginaw, Michigan
Author: Smith, Hinchman and Grylls Associates, Inc.(a)
Date: Designed in 1973, to be completed in 1975
Use of building: Federal office building with post office
Duration of operation:
Location: Saginaw, Michigan
    Latitude: 43°N
    Altitude: 600 ft.
    Normal degree-days/year: 6982 (Lansing)
    Ave. Jan. solar intensity on horizontal surface: 121 ly/day (Lansing)
    Minimum design temperature: -10°F (Lansing)
    Ave. Jan. temperature: 24°F (Lansing)
Building, floor area heated: 59,500 sqft. (gross), 125,500 sqft. (site)
    Number of heated levels: One(b)
    Windows:
    Walls:
    Roof:
    Indoor design temperature:
    Design (max.) heat load:
    Ave. Jan. heat load:
    Btu required per degree day:
    Total winter demand:
Collector, type, heat transfer fluid:
    Position, orientation, tilt above horizontal: South facing, free standing 55° tilt
    Area: 8,000 sqft. (40' x 200')
    Reflector, area and slope: None
    Type of heat transfer surface:
    Glazing:
    Cost: $4,120,000 for entire building
    Freeze protection:
Storage, type: Water
    Volume: Large
    Weight:
    Water equivalent:
    Container:
    Heat capacity:
    Normal maximum temperature:
    Jan. storage in days:
Auxiliary energy supply, type: Yes, heat pump
    Capacity:
    Mode of supply to system:
Heat collection and distribution:
    Transfer to storage:
    Motor requirement:
    Transfer to rooms:
    Motor requirement:
    Collector flow rate:
    House flow rate:
Hot water supply:
    Auxiliary heat:
    Solar source:
    Transfer means:
Automatic controls:
    Collector and storage thermostats:
    Automatic control of auxiliary:
    Automatic valves and dampers:
    Heating direct from collector:
    Automatic data recording:
    Pyroheliometer on site:
Cooling:
    Heat disposal method:
    Auxiliary cooling:
    Power required:
    Heat removal from rooms:
Performance:
    Period:
    Ave. collector efficiency while operating:
    Ave. collector efficiency, total radiation:
    Total winter heat supply by solar:
    Auxiliary energy supply:
    Heat equivalent of auxiliary:
    Percent load supplied by solar:
    Expected (theoretical) performance:

Other Comments:

(a) Project architects : J. R. Pinnell, L. Klevering, J. Kuschel (all of SH & G). Mechanical engineers : G. MacVeigh L. Schofer. Solar consultant : Dr. E. Farber.

(b) Building is partially buried and roof is landscaped as a playground.

(c) uses recycled construction materials.

(d) conserves water, uses rain water for irrigation, uses recycled mineral oil for toilet waste system.

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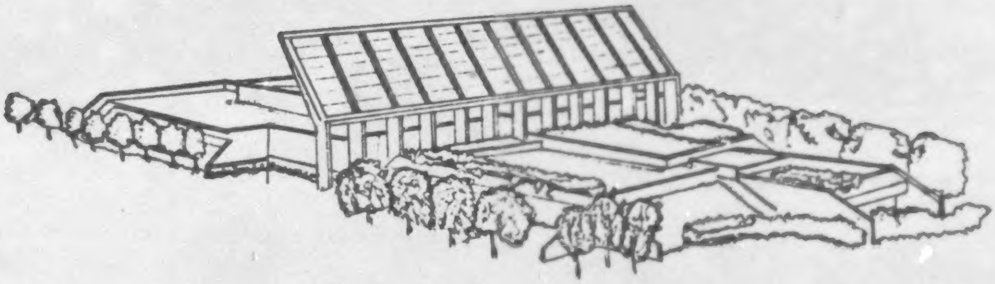

FEDERAL BUILDING, SAGINAW, MICHIGAN

Building name: SOLAR OFFICE
Author: James Schoenfelder
Date: 12/1/75
Use of building: Office
Duration of operation: One year
Location: Mead, Nebraska
Latitude: 42°N
Altitude: 1200 ft Approx.
Normal degree-days/year: 6160
Ave. Jan. solar intensity on horizontal surface: 118 BTU/SF/Hour
Minimum design temperature: -25°F
Ave. Jan. temperature: 22.6°F
Building, floor area heated: 1764
Number of heated levels: One
Windows:
Walls:
Roof:
Indoor design temperature: 70°
Design (max.) heat load: 34,200 BTU/H
Ave. Jan. heat load: 17,000 BTU/H
Btu required per degree day: 8592 BTU
Total winter demand: 52,926,720 BTU
Collector, type, heat transfer fluid: Air
Position, orientation, tilt above horizontal: South Wall; 90°
Area: 800
Reflector, area and slope:
Type of heat transfer surface: Galv. Iron, Zinc Oxide primer, no Selective Coating
Glazing: - PPG Heculite 5/8 insulating
Cost:
Freeze protection:
Storage, type: Eutectic Salt
Volume:
Weight:
Water equivalent:
Container:
Heat capacity:
Normal maximum temperature: 100°F
Jan. storage in days:
Auxiliary energy supply, type: Electric Back Up
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage:
Motor requirement:
Transfer to rooms:
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling:
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance:

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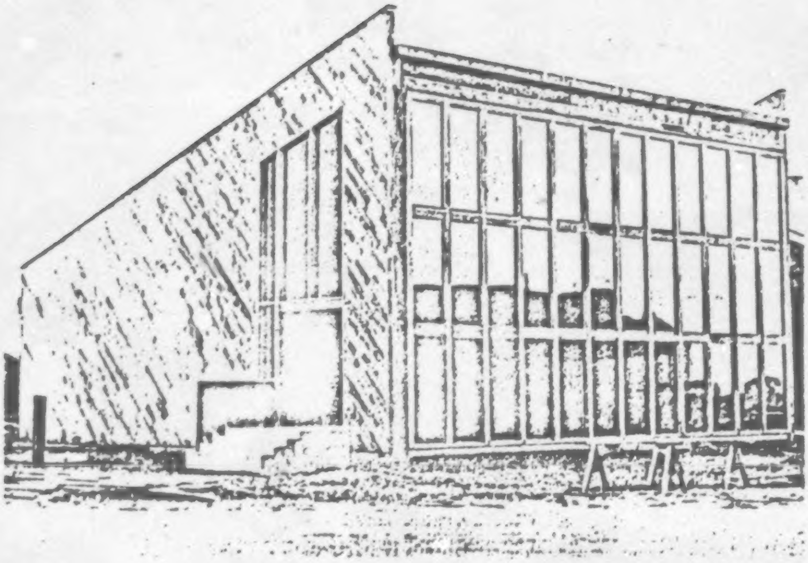

SOLAR OFFICE

3.6

Building name: SOLAR HOUSE
Author: James Schoenfelder
Date: 12/1/75
Use of building: Residence
Duration of operation: Under construction
Location: Ashland, Nebraska
Latitude: 42°N
Altitude: 1060 ft Approx.
Normal degree-days/year: 6160
Ave. Jan. solar intensity on horizontal surface: 118 BTU/SF/Hour
Minimum design temperature: -25°F
Ave. Jan. temperature: 22.6°F
Building, floor area heated: 2,500 SF
Number of heated levels: Two W/Basement
Windows:
Walls:
Roof:
Indoor design temperature: 70°F
Design (max.) heat load: 56,500 BTU/H
Ave. Jan. heat load: 28,200 BTU/H
Btu required per degree day: 14,280 BTU
Total winter demand: 87,964,800 BTU
Collector, type, heat transfer fluid: Air
Position, orientation, tilt above horizontal: South Wall; 90°
Area: 1300 SF
Reflector, area and slope:
Type of heat transfer surface: Galv. Iron, Non-Selective Coating
Glazing: PPG Herculite 7/8" insulating
Cost:
Freeze protection: None
Storage, type: Eutectic Salt
Volume:
Weight:
Water equivalent:
Container:
Heat capacity:
Normal maximum temperature: 100°F
Jan. storage in days:
Auxiliary energy supply, type: Heat Pump Back Up
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage:
Motor requirement:
Transfer to rooms:
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling:
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance:

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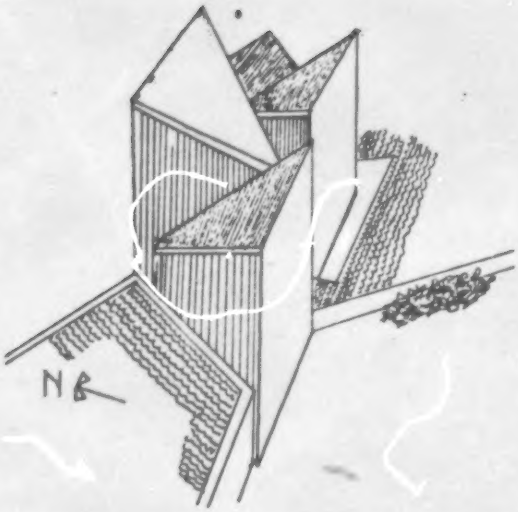

SOLAR HOUSE

3.7

- **Building name:** SOLAR VACATION HOUSE
- **Author:** Michael Jantzen
- **Date:** March 1975
- **Use of building:** Vacation house
- **Duration of operation:** Throughout the year, only two to three days at a time
- **Location:** Carlyle, Illinois
  - **Latitude:** 38°
  - **Altitude:** 560 ft.
  - **Normal degree-days/year:** 4800
  - **Ave. Jan. solar intensity on horizontal surface:** 170 ly/Day
  - **Minimum design temperature:** -10°F
  - **Ave. Jan. temperature:** 30°
- **Building, floor area heated:** 650 sq ft
  - **Number of heated levels:** 2
  - **Windows:** 4
  - **Walls:** Steel and Wood
  - **Roof:** Steel
  - **Indoor design temperature:** 70°
  - **Design (max.) heat load:**
  - **Ave. Jan. heat load:**
  - **Btu required per degree day:**
  - **Total winter demand:**
- **Collector, type, heat transfer fluid:** Water, 20% glycol
  - **Position, orientation, tilt above horizontal:** South Facing
  - **Area:** 60 sq ft
  - **Reflector, area and slope:** 60 sq ft slope adjustable depending on time of year & angle of sun
  - **Type of heat transfer surface:** direct input to interior and focus heat from reflectors to black metal and then to water
  - **Glazing:** FILON greenhouse type corrigated fiberglass
  - **Cost:** Approx. $350.00 for all solar gathering and collection devices
  - **Freeze protection:** Antifreeze
- **Storage, type:**
  - **Volume:** 32 cubic feet of water
  - **Weight:** 2000 lb.
  - **Water equivalent:**
  - **Container:** Coated galvanized metal
  - **Heat capacity:**
  - **Normal maximum temperature:**
  - **Jan. storage in days:** 1 night
- **Auxiliary energy supply, type:** Electric Space Heater
  - **Capacity:** 16,500 BTU
  - **Mode of supply to system:** 240 V 4800 Watts
- **Heat collection and distribution:**
  - **Transfer to storage:** direct input
  - **Motor requirement:** None
  - **Transfer to rooms:** direct radiation
  - **Motor requirement:** None
  - **Collector flow rate:**
  - **House flow rate:**
- **Hot water supply:**
  - **Auxiliary heat:** Electric water heater
  - **Solar source:**
  - **Transfer means:**
- **Automatic controls:**
  - **Collector and storage thermostats:** None
  - **Automatic control of auxiliary:** thermostat
  - **Automatic valves and dampers:** None
  - **Heating direct from collector:** yes rise conduction
  - **Automatic data recording:** None
  - **Pyroheliometer on site:**
- **Cooling:**
  - **Heat disposal method:** Rotating ventilators
  - **Auxiliary cooling:** blower removes 650 cubic feet of free air per minute
  - **Power required:** Electricity
  - **Heat removal from rooms:**
- **Performance:**
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:** at 5° ext. interior can reach 100°int.
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:**
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:**

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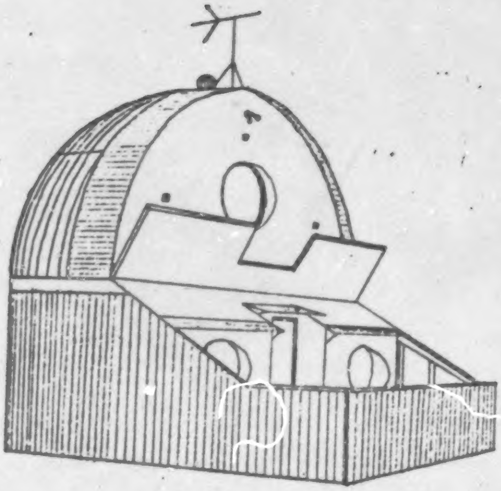
Personal Correspondence



SOLAR VACATION HOUSE

At a cost of $15.00 plans for the Solar Vacation House can be obtained. Write to Michael Jantzen, Box 172, Carlyle, Illinois 62231

3.8

Building name: NEW CENTURY TOWN
Author:
Date: 2/29/76
Use of building: Residence
Duration of operation: expected March 1976
Location: Vernon Hills, Illinois
  Latitude: 42°N
  Altitude: 350 ft
  Normal degree-days/year: 6500
  Ave. Jan. solar intensity on horizontal surface: 150 ly/Day
  Minimum design temperature: -10°
  Ave. Jan. temperature: 25°
Building, floor area heated: 4 houses connected
  Number of heated levels:
  Windows:
  Walls:
  Roof:
  Indoor design temperature:
  Design (max.) heat load:
  Ave. Jan. heat load:
  Btu required per degree day:
  Total winter demand:
Collector, type, heat transfer fluid:
  Position, orientation, tilt above horizontal:
  Area:
  Reflector, area and slope:
  Type of heat transfer surface:
  Glazing:
  Cost:
  Freeze protection:
Storage, type: Water
  Volume: 1000 gal.
  Weight:
  Water equivalent:
  Container:
  Heat capacity:
  Normal maximum temperature:
  Jan. storage in days:
Auxiliary energy supply, type: Gas or electric hot water heater
  Capacity:
  Mode of supply to system:
Heat collection and distribution: Water to water heat pump
  Transfer to storage:
  Motor requirement:
  Transfer to rooms:
  Motor requirement:
  Collector flow rate:
  House flow rate:
Hot water supply: Gas or electric same as aux. energy supply
  Auxiliary heat:
  Solar source:
  Transfer means:
Automatic controls:
  Collector and storage thermostats:
  Automatic control of auxiliary:
  Automatic valves and dampers:
  Heating direct from collector:
  Automatic data recording:
  Pyroheliometer on site:
Cooling:
  Heat disposal method:
  Auxiliary cooling:
  Power required:
  Heat removal from rooms:
Performance:
  Period:
  Ave. collector efficiency while operating:
  Ave. collector efficiency, total radiation:
  Total winter heat supply by solar:
  Auxiliary energy supply:
  Heat equivalent of auxiliary:
  Percent load supplied by solar:
  Expected (theoretical) performance: 60%

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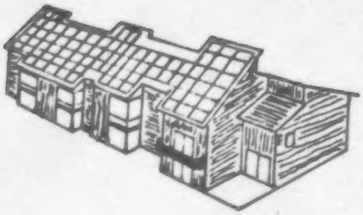
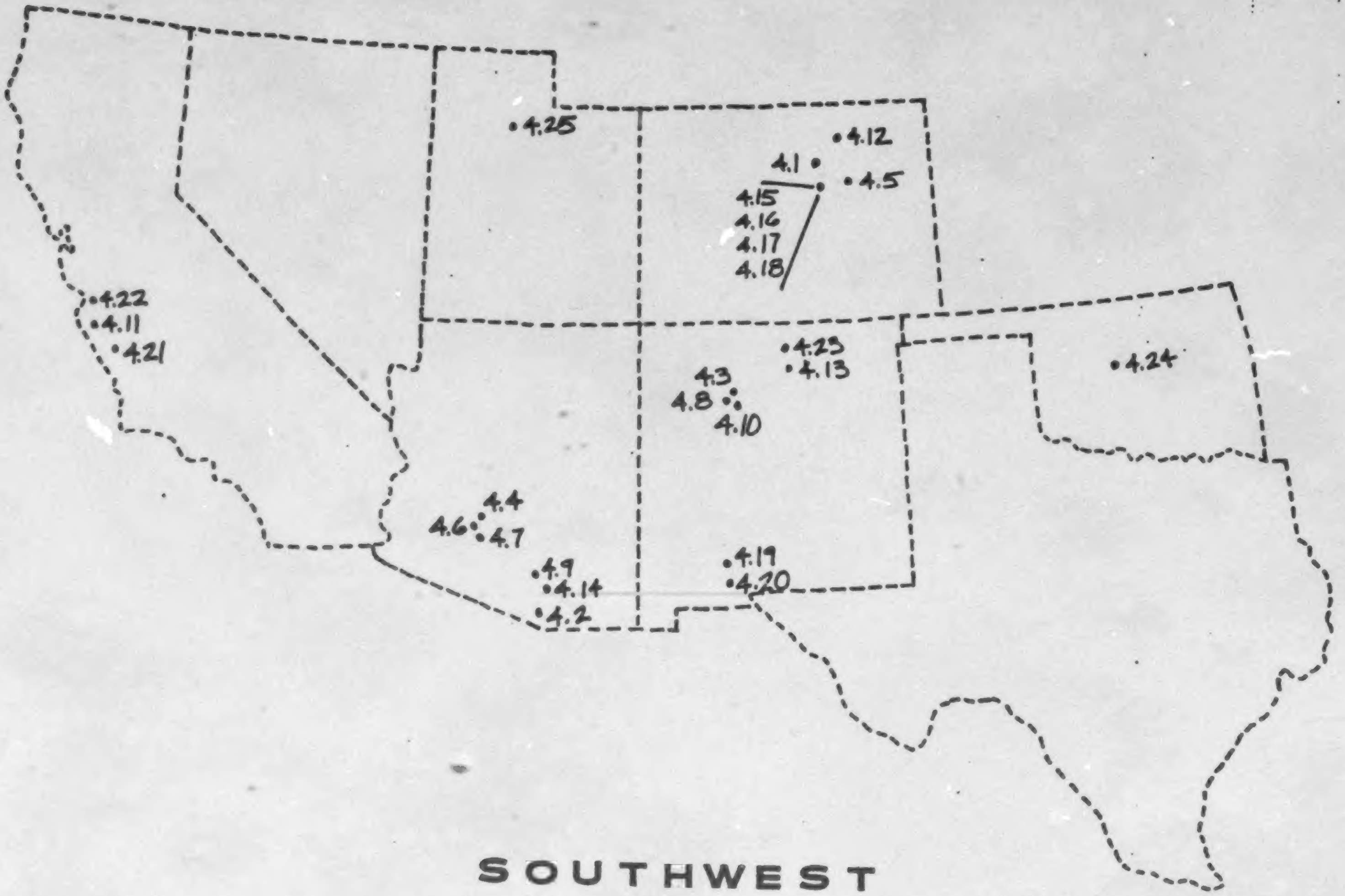


NEW CENTURY TOWN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4.2

SOUTHWEST

4.1

Building name: University of Colorado
Author:
Date: Added to house in 1946
Use of building: Residence
Duration of operation: 1945 through 1948 (published)
Location: Boulder, Colorado
Latitude: 40°N
Altitude: 5400 ft.
Normal degree-days/year: 6100
Ave. Jan. solar intensity on horizontal surface: 220 ly/day
Minimum design temperature: 0°F
Ave, Jan. temperature: 29°F
Building, floor area heated: Approx. 850 sqft. (estimated by author)
Number of heated levels: One
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Air heating
Position, orientation, tilt above horizontal: On south roof, 27° slope
Area: 463 sqft.
Reflector, area and slope: None
Type of heat transfer surface: Overlapped glass plates
Glazing: 3 or 4 sheets of glass
Cost:
Freeze protection: None
Storage, type: Stone, 3/4" dia.(a)
Volume: 180 cuft.
Weight: 16,600 lb. (8.3 tons)
Water equivalent: 3,300 gal.
Container:
Heat capacity: 216,000 Btu(b)
Normal maximum temperature: 140°F(b)
Jan. storage in days:
Auxiliary energy supply, type: Yes, gas furnace
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: None
Motor requirement: None
Transfer to rooms: Furnace fan used to blow air through collector into house
Motor requirement: Furnace fan
Collector flow rate:
House flow rate:
Hot water supply: Yes, preheat
Auxiliary heat: Automatic gas water heater
Solar source: Hot air from collector
Transfer means: Air-water heat exchanger (fin tube)
Automatic controls: Full
Collector and storage thermostats: Collector and room thermostats
Automatic control of auxiliary: Yes
Automatic valves and dampers: Damper motor
Heating direct from collector: Yes
Automatic data recording:
Pyrheliometer on site:
Cooling: None
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period: 1946-1947 winter
Ave. collector efficiency while operating: 35%
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar: 20% of heat load
Expected (theoretical) performance:

Other comments:

Solar heating was provided as auxiliary to gas furnace; no storage provided except 120 gallon hot water preheater located in attic. Furnace fan was used (with various dampers) to blow air through collector and the rooms of the house. Hot air supply was from registero in ceilings in center of rooms; cold air returns were located at floor at the house perimeter. Problem encountered with collector glass breakage from thermal stress.

Roof originally had a 240 square foot collector (1945); original source for heat trap research was War Production Board's Office of Production Research and Development.

(a) No storage was mentioned in the first four references; Shurcliff describes storage.

(b) Estimated and calculated by R. Gray.

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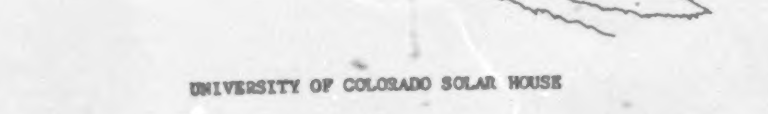

UNIVERSITY OF COLORADO SOLAR HOUSE

4.2

- Building name: U. S. Forest Service Desert Grassland Station
- Author: R. W. Bliss and M. K. Donovan (architects & engineers)
- Date: 1954
- Use of building: Residence at Desert Grassland Station
- Duration of operation: system demolished in 1956
- Location: Amado, Arizona
    - Latitude: 32° N
    - Altitude: 3,800 ft.
    - Normal degree-days/year: 1800
    - Ave. Jan. solar intensity on horizontal surface: 315 langleys/day (Tucson)
    - Minimum design temperature: 23° (Tucson)
    - Ave. Jan. temperature: 48°
- Building, floor area heated: 672 ft^2
    - Number of heated levels: one
    - Windows:
    - Walls:
    - Roof:
    - Indoor design temperature:
    - Design (max.) heat load:
    - Ave. Jan. heat load:
    - Btu required per degree day:
    - Total winter demand:
- Collector, type, heat transfer fluid: air
    - Position, orientation, tilt above horizontal: south facing, 53° slope
    - Area: 315 ft^2
    - Reflector, area and slope: none
    - Type of heat transfer surface: four layers of black cotton cloth spaced ⅛" apart
    - Glazing: single glass
    - Cost: $4,000
    - Freeze protection: None
- Storage, type: rocks (4 in. stones)
    - Volume: 1350 cu. ft.
    - Weight: 65 tons
    - Water equivalent: 26,000 lb. 3100 gals.
    - Container: insulated underground bin
    - Heat capacity:
    - Normal maximum temperature:
    - Jan. storage in days: 10 days (average)
- Auxiliary energy supply, type: electrical resistance
    - Capacity: full
    - Mode of supply to system: used as needed
- Heat collection and distribution:
    - Transfer to storage: blower
    - Motor requirement:
    - Transfer to rooms: blower
    - Motor requirement:
    - Collector flow rate:
    - House flow rate:
- Hot water supply: none
    - Auxiliary heat:
    - Solar source:
    - Transfer means:
- Automatic controls:
    - Collector and storage thermostats:
    - Automatic control of auxiliary:
    - Automatic valves and dampers:
    - Heating direct from collector: yes
    - Automatic data recording:
    - Pyroheliometer on site:
- Cooling: yes
    - Heat disposal method: night sky radiation
    - Auxiliary cooling: none
    - Power required:
    - Heat removal from rooms:
- Performance:
    - Period: 1954-56
    - Ave. collector efficiency while operating:
    - Ave. collector efficiency, total radiation:
    - Total winter heat supply by solar:
    - Auxiliary energy supply: none needed
    - Heat equivalent of auxiliary:
    - Percent load supplied by solar: 100%
    - Expected (theoretical) performance:

Comments

Storage bin had 4" concrete floor, 7" concrete walls and 8" rock wool ceiling. Stores 1.35×10^6 BTU between 140°F and 90°F for 10 average days.

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Towne School of Civil and Mechanical Engineering, Conservation and Better Utilization of Electric Power by Means of Thermal Energy Storage and Solar Heating, Oct., 1971 (NTIS PB-210359).

4.3

Building name: Solar Office Building, Bridges and Paxton
Author: Bridges & Paxton Engineers, Stanley & Wright, architects
Date: 1956
Use of building: Office of Bridges & Paxton, Engineers
Duration of operation: 1956 - 1964(d)
Location: Albuquerque, New Mexico
Latitude: 35°N
Altitude: Approx. 4,500 ft.
Normal degree-days/year: 4500
Ave. Jan. solar intensity on horizontal surface: 300 ly/day
Minimum design temperature: 0°F
Ave. Jan. temperature: 34°F
Building, floor area heated: 4,300 sqft.
Number of heated levels: One
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Water + ethelene glycol
Position, orientation, tilt above horizontal: South wall, 60° tilt
Area: 800 sqft.
Reflector, area and slope: None (except pavement)
Type of heat transfer surface: Bonded aluminum sheets with flow channels
Glazing: Single
Cost: Mechanical with collector, $17,400; building total, $58,500; $3,000 above conventional(c)
Freeze protection: Drain collector
Storage, type: Hot water (or cold water)(a)
Volume: 6,000 gal.
Weight: 50,000 lb.
Water equivalent: Same
Container: Tank
Heat capacity: 5.25 million Btu ($\Delta t = 140^\circ - 35^\circ = 105^\circ F$)
Normal maximum temperature: 140°F
Jan. storage in days: 3 days
Auxiliary energy supply, type: Yes, electric (or fuel, auxiliary water heater); one electric heat pump and water heater
Capacity: 7.5 tons heat pump
Mode of supply to system: Heats or cools storage tank(a)
Heat collection and distribution:
Transfer to storage: Store hot (or cold) water(a) Heat exchanger
Motor requirement: Pump
Transfer to rooms: Radiant water piping in ceiling and floors, conditioned ventilation air (a)
Motor requirement: Pump
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls: Manual controls on collector
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector: No (except through insulation)
Automatic data recording: Since 1974
Pyroheliometer on site: Since 1974
Cooling: Yes
Heat disposal method: Evaporative cooling tower
Auxiliary cooling: Electric heat pump
Power required: One 7.5 ton heat pump
Heat removal from rooms: Radiant (water) piping in ceiling and floor, conditioned ventilation air
Performance:
Period: 1956
Ave. collector efficiency while operating: Varies from 85% at 40°F to 35% at 110°F collector temperature
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar: 53% (fuel savings)(b) 1974 60% of building 100% solar
Expected (theoretical) performance:

Other Comments:

(a) Modes of operation:

(1) Winter day heat flow : solar collector (110° to 140°) to storage tank to room radiant panels (110° supply).

(2) Winter night heat flow : storage tank to heat pump to room radiant panels. Heat pump suppresses storage down to 35° F. to keep room supply at 110° F.

(3) Summer, 85° F outside, heat flow : evaporative water cooler supplies 70° F. water to room panels for cooling while the collector heats the storage for nights heating.

(4) Summer, 90° F. outside, heat flow : evaporative water cooler supplies 65° F. water to storage tank and then to rooms for cooling, (collector is not used)

(5) Summer, 100° F. outside, heat flow : heat pump cools storage to 60° F. or less, which then cools rooms radiant panels : the heat pump supplies 100° F. water to the evaporative cooler, which returns 85° F water to the heat pump. (collector is not used)

(b) During a cold January, operating the electric heat pump cost $78.00 while conventional gas heating would have cost $169.00 to operate.

(c) The 53% fuel savings would have justified an extra investment of $1,000, but not $3,000 in 1956.

(d) Collector operation ended in 1964 due to rubber hose rotting, and the nuisance of the manual controls, and collector freezing. Stanley Gilman, Penn. State University, has a NSF grant to renovate and instrument the solar system. The building will be equipped with a four pipe hot and cold water loop, zoned heat pump system to add internal heat recovery to the solar collection. Then solar should supply 50% to 75% of the heating load.

(e) In 1974-5 small heat pumps were added (10 KW Total)
cop 3 to 3.5

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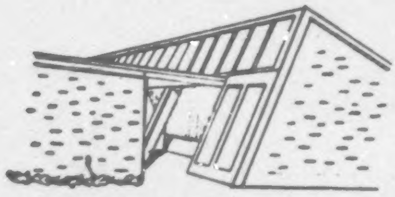

SOLAR OFFICE BUILDING, BRIDGES & PAXTON

4.4

- **Building name:** First prize winner in competition sponsored by Association for Applied Solar Energy
- **Author:** Peter Lee (student at University of Minnesota)
- **Date:** Constructed spring, 1958
- **Use of building:** Laboratory
- **Duration of operation:**
- **Location:** Scottsdale, Arizona
  - **Latitude:** 33°N
  - **Altitude:** 1100 ft.
  - **Normal degree-days/year:** 1441
  - **Ave. Jan. solar intensity on horizontal surface:** 300 ly/day
  - **Minimum design temperature:** +25°F
  - **Ave. Jan. temperature:** 51°F
- **Building, floor area heated:**
  - **Number of heated levels:** one storey
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:**
  - **Design (max.) heat load:**
  - **Ave. Jan. heat load:**
  - **Btu required per degree day:**
  - **Total winter demand:**
- **Collector, type, heat transfer fluid:** Water heating
  - **Position, orientation, tilt above horizontal:** Suspended over two patios, facing south, adjustable tilt
  - **Area:** 4 panels per row, 16 rows
  - **Reflector, area and slope:** None
  - **Type of heat transfer surface:** Copper tubes on copper plate
  - **Glazing:** Two layers mylar film (back: dacron insulation with aluminum cover)
  - **Cost:**
  - **Freeze protection:**
- **Storage, type:** Water, hot in winter, cool in summer also swimming pool 20,000 gal.
  - **Volume:** 2,000 gal.
  - **Weight:** 16,700 lb.
  - **Water equivalent:** Same
  - **Container:** Buried tank
  - **Heat capacity:** 1.1 million Btu at 65°F$\Delta t^{(a)}$
  - **Normal maximum temperature:**
  - **Jan. storage in days:**
- **Auxiliary energy supply, type:** Yes, electric heat pump
  - **Capacity:**
  - **Mode of supply to system:**
- **Heat collection and distribution:**
  - **Transfer to storage:**
  - **Motor requirement:**
  - **Transfer to rooms:**
  - **Motor requirement:**
  - **Collector flow rate:**
  - **House flow rate:**
- **Hot water supply:** Heat domestic water and warm swimming pool
  - **Auxiliary heat:**
  - **Solar source:**
  - **Transfer means:**
- **Automatic controls:**
  - **Collector and storage thermostats:**
  - **Automatic control of auxiliary:**
  - **Automatic valves and dampers:**
  - **Heating direct from collector:**
  - **Automatic data recording:**
  - **Pyroheliometer on site:**
- **Cooling:** Cooling provided
  - **Heat disposal method:** spray in swimming pool
  - **Auxiliary cooling:** Electric heat pump
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:**(b)
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:**
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:**
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:**

Other comments:

[a] Calculated by R. Gray

[b] Due to legal complications the solar system was seldom used and never fully tested. It is partially intact and the heat pumps have been used.

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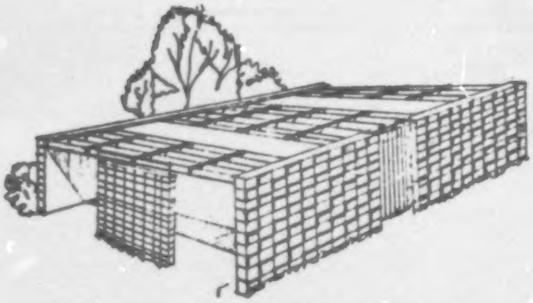

FIRST PRIZE WINNER IN COMPETITION BY
ASSOC. FOR APPLIED SOLAR ENERGY

4.5

- **Building name:** Colorado Solar House
- **Author:** George Lof, M.M. Wakil
- **Date:** Constructed in 1959
- **Use of building:** Residence
- **Duration of operation:** In use since 1959
- **Location:** Near Denver, Colorado
  - **Latitude:** 40°N
  - **Altitude:** 5400 ft.
  - **Normal degree-days/year:** 6100
  - **Ave. Jan. solar intensity on horizontal surface:** 220 ly/day
  - **Minimum design temperature:** 0°F
  - **Ave. Jan. temperature:** 29°F
- **Building, floor area heated:** 3,200 sqft.
  - **Number of heated levels:** 1-1/2
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:** 70°
  - **Design (max.) heat load:** 108,500 Btu/hr
  - **Ave. Jan. heat load:** 50,000 Btu/hr
  - **Btu required per degree day:** 32,000 Btu
  - **Total winter demand:** 194,000,000 Btu
- **Collector, type, heat transfer fluid:** Air heating
  - **Position, orientation, tilt above horizontal:** On flat roof, 45° slope
  - **Area:** 600 sqft (two rows, 6'x50')
  - **Reflector, area and slope:** None
  - **Type of heat transfer surface:** Overlapped black glass plates, 3 or 4 deep
  - **Glazing:** Single glass on cool end, double glass on hot end
  - **Cost:** $2,100 (estimated cost, 1955)
  - **Freeze protection:** Air as transfer fluid
- **Storage, type:** Rocks, 1-1/2" diameter
  - **Volume:** 250 cuft.
  - **Weight:** 12 tons (24,000 lb.)
  - **Water equivalent:** 516 gal.(a)
  - **Container:** Two fibre cylinders, 3' dia. x 18' high
  - **Heat capacity:** 0.3 million Btu
  - **Normal maximum temperature:** 140°F
  - **Jan. storage in days:** 1/4 day
- **Auxiliary energy supply, type:** Yes, natural gas furnace
  - **Capacity:** 100,000 Btu/hr
  - **Mode of supply to system:** Heat air from collector or storage
- **Heat collection and distribution:**
  - **Transfer to storage:** Hot air to rocks
  - **Motor requirement:** 1-1/4 H.P. blower
  - **Transfer to rooms:** House air through rocks
  - **Motor requirement:** 1 H.P. requirement
  - **Collector flow rate:** 770 cuft/min
  - **House flow rate:** 782 cuft/min
- **Hot water supply:** Yes, preheat
  - **Auxiliary heat:** Automatic gas heater
  - **Solar source:** Hot air from collector
  - **Transfer means:** Air-water heat exchanger
- **Automatic controls:** Full
  - **Collector and storage thermostats:** Collector and storage
  - **Automatic control of auxiliary:** Yes
  - **Automatic valves and dampers:** Two pairs of dampers
  - **Heating direct from collector:** Yes
  - **Automatic data recording:** Yes
  - **Pyrheliometer on site:** Yes
- **Cooling:** No
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:**
  - **Period:** 1959-1960 winter
  - **Ave. collector efficiency while operating:** 34.6%
  - **Ave. collector efficiency, total radiation:** 24.5%
  - **Total winter heat supply by solar:** 51.7 million Btu
  - **Auxiliary energy supply:** 230,000 cuft. gas
  - **Heat equivalent of auxiliary:** 141.8 million Btu
  - **Percent load supplied by solar:** 26.5%
  - **Expected (theoretical) performance:**

Other comments:

Architect - James M. Hunter, Boulder, Colorado.

Cost of conventional heating system would have been $1,300.

(a) Based on Löf, bulk density of rock is 96 lb/cuft., and specific heat is 0.18.

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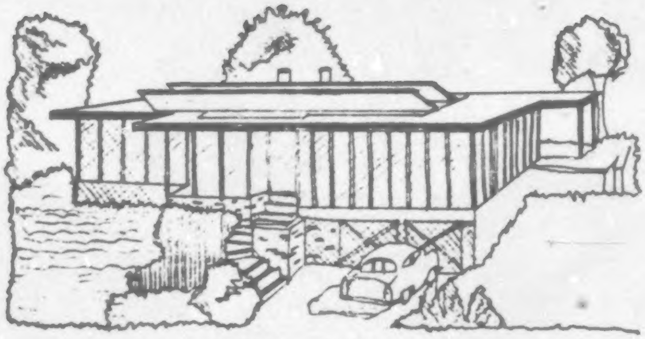

COLORADO SOLAR HOUSE

4.6

- **Building name:**
- **Author:** Bliss
- **Date:** 1960
- **Use of building:** Laboratory
- **Duration of operation:** Demolished in 1970
- **Location:** Phoenix, Arizona
  - **Latitude:** 32°N
  - **Altitude:** 2600 ft.
  - **Normal degree-days/year:** 1800
  - **Ave. Jan. solar intensity on horizontal surface:** Approx. 300 ly/day
  - **Minimum design temperature:** 30°F
  - **Ave. Jan. temperature:** 51°F
- **Building, floor area heated:** 1,440 sqft.
  - **Number of heated levels:** One
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:** 75°
  - **Design (max.) heat load:** Approx. 35,000 Btuh
  - **Ave. Jan. heat load:** Approx. 20,000 Btuh(a)
  - **Btu required per degree day:** Approx. 18,000 Btu(a)
  - **Total winter demand:** 35.3 million (1959-1960)
- **Collector, type, heat transfer fluid:** Water heating
  - **Position, orientation, tilt above horizontal:** On south roof, 7° tilt
  - **Area:** 1,623 sqft.
  - **Reflector, area and slope:** None
  - **Type of heat transfer surface:** Expanded copper tubed sheet
  - **Glazing:** None
  - **Cost:**
  - **Freeze protection:**
- **Storage, type:** Water
  - **Volume:** 4,500 gal.
  - **Weight:** 19 tons (37,600 lb.)
  - **Water equivalent:** Same
  - **Container:** 2-section tank, lower half night cooled in summer
  - **Heat capacity:** Approx. 1.3 million Btu(b)
  - **Normal maximum temperature:** 110°F(b)
  - **Jan. storage in days:**
- **Auxiliary energy supply, type:** Yes, electric heat pump
  - **Capacity:** 1-1/2 H.P. compressor motor
  - **Mode of supply to system:** "Pump" to hot storage section
- **Heat collection and distribution:**
  - **Transfer to storage:** Store hot water
  - **Motor requirement:** 1/4 H.P. pump
  - **Transfer to rooms:** Hot water in radiant ceiling
  - **Motor requirement:** 1/4 H.P. pump
  - **Collector flow rate:**
  - **House flow rate:**
- **Hot water supply:** No
  - **Auxiliary heat:**
  - **Solar source:**
  - **Transfer means:**
- **Automatic controls:** Full
  - **Collector and storage thermostats:** Collector and storage
  - **Automatic control of auxiliary:** Yes
  - **Automatic valves and dampers:** Yes
  - **Heating direct from collector:** No(c,d)
  - **Automatic data recording:** Yes
  - **Pyrohelicmeter on site:** Yes
- **Cooling:** Yes
  - **Heat disposal method:** Night radiation and convection
  - **Auxiliary cooling:** Heat pump
  - **Power required:** 1-1/2 H.P.
  - **Heat removal from rooms:** Cool water in ceiling panels
- **Performance:**
  - **Period:** 1959-1960 winter
  - **Ave. collector efficiency while operating:** 28.7% (Jan. only)
  - **Ave. collector efficiency, total radiation:** 37.2% (Jan. only)
  - **Total winter heat supply by solar:** 30.3 million Btu(a)
  - **Auxiliary energy supply:** 1470 kWh = 5.0 million Btu
  - **Heat equivalent of auxiliary:** Approx. 17,000,000 Btu(a,e)
  - **Percent load supplied by solar:** 86%(a,f); 64%(a,g)
  - **Expected (theoretical) performance:**

Other comments:

[a] Estimated or computed by Löf.

[b] Uncertain estimate by Löf.

[c] All of the solar heat supplied to building via storage unit.

[d] System arranged for space heating directly from solar heat storage (usual) or from heat-pump condenser storage section.

[e] Computed by assuming average steam-power plant efficiency at 30%.

[f] Based on equal heating effectiveness of work and heat, i.e. 1 kWh = 3412 Btu.

[g] Based on note (e), the efficiency then being effeccively the heat supplied to the house by solar divided by the sum of this quantity plus the heat from fuel burned in an average power plant to produce the required electric energy.

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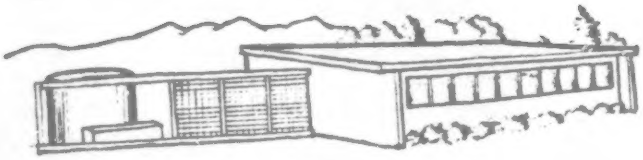

BLISS LABORATORY

4.7

Building name: Skytherm prototype
Author: Harold Hay, John Yellott
Date: 1967
Use of building: Laboratory
Duration of operation: 1967 - 1968 test
Location: Phoenix, Arizona
- Latitude: 32°26'N
- Altitude: 1100 ft.
- Normal degree-days/year: 1492
- Ave. Jan. solar intensity on horizontal surface: approx. 300 ly/day
- Minimum design temperature: 32°F
- Ave. Jan. temperature: 51°F

Building, floor area heated: 170 sqft. (10' x 12')
- Number of heated levels:
- Windows:
- Walls:
- Roof:
- Indoor design temperature: Resulting winter temperature, 66°-73°F; summer temperature, 74°-77°F
- Design (max.) heat load:
- Ave. Jan. heat load:
- Btu required per degree day:
- Total winter demand:

Collector, type, heat transfer fluid: Water
- Position, orientation, tilt above horizontal: Horizontal on roof
- Area: 170 sqft. (11' x 15-1/2')
- Reflector, area and slope: None
- Type of heat transfer surface: Clear plastic bag with 7 in. water over black plastic
- Glazing: None, movable insulation, 1-1/2" thick
- Cost:
- Freeze protection:

Storage, type: Water
- Volume: 450 gal.
- Weight: 3,760 lb.
- Water equivalent: Same (thermal capacity equal to 12" conc., weight equal to 3" conc.)
- Container: Clear plastic bag
- Heat capacity: 7,500 Btu at 20°Δt
- Normal maximum temperature: 85°F
- Jan. storage in days:

Auxiliary energy supply, type: None
- Capacity:
- Mode of supply to system:

Heat collection and distribution:
- Transfer to storage: Store in collector
- Motor requirement: None, manual operation of movable insulation
- Transfer to rooms: From water, or black plastic liner which heats up first, through metal deck
- Motor requirement: None
- Collector flow rate:
- House flow rate:

Hot water supply:
- Auxiliary heat:
- Solar source:
- Transfer means:

Automatic controls: None
- Collector and storage thermostats: None
- Automatic control of auxiliary: N.A.
- Automatic valves and dampers: None
- Heating direct from collector: Yes
- Automatic data recording:
- Pyroheliometer on site:

Cooling: Yes, outdoor temperature 100°F max.; 84°F 24 hour ave. max.
- Heat disposal method: Night sky radiation
- Auxiliary cooling: None
- Power required: None
- Heat removal from rooms: Cool ceiling, radiation and convection

Performance:
- Period:
- Ave. collector efficiency while operating:
- Ave. collector efficiency, total radiation:
- Total winter heat supply by solar:
- Auxiliary energy supply:
- Heat equivalent of auxiliary:
- Percent load supplied by solar:
- Expected (theoretical) performance:

Other comments:

Cooling: Day outdoor 100°F peak, 84°F 24 hr. ave. indoor 74°-77°F. Evaporative cooling: Flood water bags with thin layer of water. Nighttime evaporation further cooled water to below air min. 1/8 to 1/4 inch evaporated, losing 1.37 gallons of water which produces the effect of 1 ton of cooling.

Evaporative cooling: Outdoor 108°F max, 87°F ave., indoor 77°-82°F
Outdoor 115°F max, 95°F four-day average, indoor 95°F, and at this limit a fan coil was was needed to transfer heat in stratified room air to cool pond overhead

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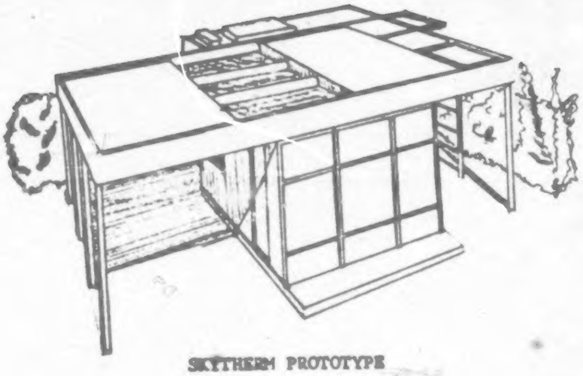

SKYTHERM PROTOTYPE

4.8

- Building name: Zome
- Author: Steven Baer
- Date: 1971
- Use of building: Residence
- Duration of operation:
- Location: Albuquerque, New Mexico; suburb Corrales
    - Latitude: 35°N
    - Altitude: Approx. 5,100 ft.
    - Normal degree-days/year: 4500
    - Ave. Jan. solar intensity on horizontal surface: 300 ly/day
    - Minimum design temperature: 0°F
    - Ave. Jan. temperature: 34°F
- Building, floor area heated: Cluster of ten domes, 2,000 sqft.
    - Number of heated levels: One storey
    - Windows:
    - Walls:
    - Roof:
    - Indoor design temperature:
    - Design (max.) heat load:
    - Ave. Jan. heat load:
    - Btu required per degree day:
    - Total winter demand:
- Collector, type, heat transfer fluid: Water
    - Position, orientation, tilt above horizontal: South wall; 4 staggered windows
    - Area: 180 sqft.+, 90 barrels, ends are 2 sqft. each, collector window is larger
    - Reflector, area and slope: Aluminum horizontal reflector
    - Type of heat transfer surface: Blackened ends of oil drums
    - Glazing: Single glass
    - Cost: Close insulation, storage inside heated space
    - Freeze protection:
- Storage, type: Water
    - Volume: 4,950 gal.
    - Weight: 41,300 lb.
    - Water equivalent: 4,950 gal.
    - Container: 90 oil drums on steel racks, 56 gal. each
    - Heat capacity: 0.4 million Btu at Δt = 10°F, 0.8 million Btu at Δt = 20°F(a)
    - Normal maximum temperature:
    - Jan. storage in days:
- Auxiliary energy supply, type: Yes, wood burning.pot-bellied stove
    - Capacity:
    - Mode of supply to system: Radiation, convection to house air
- Heat collection and distribution:
    - Transfer to storage: Collector is storage
    - Motor requirement: None
    - Transfer to rooms: Radiation/convection from storage; white tank ends
    - Motor requirement: None
    - Collector flow rate: None
    - House flow rate: None
- Hot water supply:
    - Auxiliary heat:
    - Solar source:
    - Transfer means:
- Automatic controls: None
    - Collector and storage thermostats:
    - Automatic control of auxiliary: No, manual operation
    - Automatic valves and dampers:
    - Heating direct from collector: Yes
    - Automatic data recording:
    - Pyroheliometer on site:
- Cooling:
    - Heat disposal method:
    - Auxiliary cooling:
    - Power required:
    - Heat removal from rooms:
- Performance:
    - Period:
    - Ave. collector efficiency while operating:
    - Ave. collector efficiency, total radiation:
    - Total winter heat supply by solar:
    - Auxiliary energy supply:
    - Heat equivalent of auxiliary:
    - Percent load supplied by solar: Approx. 90%
    - Expected (theoretical) performance:

Other Comments:

The solar collector, storage is insulated at night by a hinged panel of foam insulation sandwiched between aluminum skins. The panel serves as a reflector during the day. Operation is manual by a cable.

(a) calculated by R. Gray

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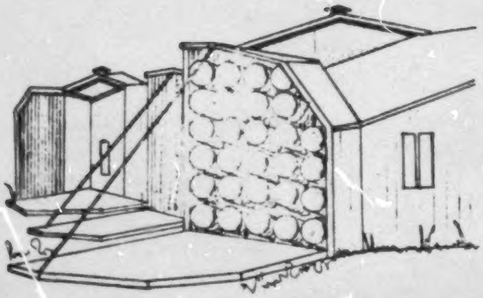

ZOME

4.9

Building name: Meinel House
Author: A. B. Meinel an M. P. Meinel
Date: added to residence in 1973
Use of building: Residence
Duration of operation: 1973-
Location: Tucson, Arizona
Latitude: 32° N
Altitude: 2600 ft.
Normal degree-days/year: 1800
Ave. Jan. solar intensity on horizontal surface: 315 ly/day
Minimum design temperature: 30°F
Ave. Jan. temperature: 42°F
Building, floor area heated: 2000 ft^2
Number of heated levels: one
Windows:
Walls: 8" adobe walls
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: air
Position, orientation, tilt above horizontal: vertical SSE wall
Area: 300 ft^2
Reflector, area and slope: 125 ft^2 horizontal reflector (roof of storage bin)
Type of heat transfer surface: black absorbing surface
Glazing: double glass
Cost:
Freeze protection: none needed
Storage, type: water; adobe walls of building
Volume: 1000 gallon
Weight: 8,360 lb.
Water equivalent:
Container: Outdoor storage bin contains 1000 spaced, water-filled, 1 gallon polyethylene bottles
Heat capacity:
Normal maximum temperature:
Jan. storage in days:
Auxiliary energy supply, type: Natural Gas
Capacity: full capacity
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: Fan
Motor requirement:
Transfer to rooms:
Motor requirement:
Collector flow rate: 1000 cfm
House flow rate:
Hot water supply: none
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling: yes
Heat disposal method: evaporative cooling is used to cool storage bin
Auxiliary cooling:
Power required:
Heat removal from rooms: room air blown over cool storage bin
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar: 20% (heating)
Expected (theoretical) performance:

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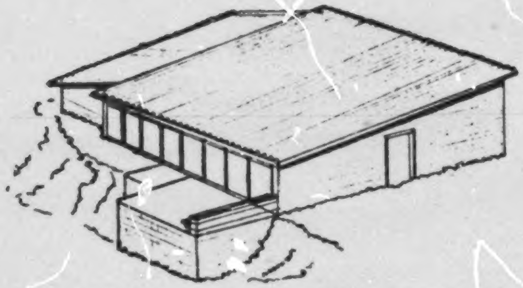

MEINEL HOUSE

4.10

- **Building name:** Prototype 1
- **Author:** Eileen and Robert Reines
- **Date:** 1973
- **Use of building:** Residence
- **Duration of operation:**
- **Location:** Albuquerque, New Mexico
  - **Latitude:** 35°N
  - **Altitude:** Approx. 5,100 ft.
  - **Normal degree-days/year:** 4500
  - **Ave. Jan. solar intensity on horizontal surface:** 300 ly/day
  - **Minimum design temperature:** 0°F (stayed warm at -30°F)
  - **Ave. Jan. temperature:** 34°F
- **Building, floor area heated:** 855 sqft., 655 ground floor, 200 sleeping loft
  - **Number of heated levels:** One + loft
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:**
  - **Design (max.) heat load:**
  - **Ave. Jan. heat load:**
  - **Btu required per degree day:**
  - **Total winter demand:**
- **Collector, type, heat transfer fluid:** Water heating
  - **Position, orientation, tilt above horizontal:** South, 45° slope (?)
  - **Area:**
  - **Reflector, area and slope:** None
  - **Type of heat transfer surface:** Copper tubes on sheet
  - **Glazing:** Single glass
  - **Cost:**
  - **Freeze protection:** Water glycol in collector
- **Storage, type:** Water
  - **Volume:** 3,000 gal.
  - **Weight:** 12 tons = 25,000 lb.
  - **Water equivalent:** 3,000 gal.
  - **Container:** Insulated tank
  - **Heat capacity:** 1.6 million Btu at $\Delta t = 65°F^{(b)}$
  - **Normal maximum temperature:**
  - **Jan. storage in days:**
- **Auxiliary energy supply, type:** Yes, three wind driven electrical generators
  - **Capacity:** (a)
  - **Mode of supply to system:**
- **Heat collection and distribution:**
  - **Transfer to storage:** Circulating water-glycol solution, heat exchanger to storage
  - **Motor requirement:**
  - **Transfer to rooms:** Circulating storage water to hot water radiators
  - **Motor requirement:** Water pump
  - **Collector flow rate:**
  - **House flow rate:**
- **Hot water supply:** Yes, fuel supply
  - **Auxiliary heat:**
  - **Solar source:** Hot water from collector storage
  - **Transfer means:** One tank in another
- **Automatic controls:**
  - **Collector and storage thermostats:**
  - **Automatic control of auxiliary:**
  - **Automatic valves and dampers:**
  - **Heating direct from collector:** No
  - **Automatic data recording:** No
  - **Pyroheliometer on site:** No
- **Cooling:** Yes
  - **Heat disposal method:** Night radiation
  - **Auxiliary cooling:** None
  - **Power required:** Circulating pump
  - **Heat removal from rooms:** Cool water through radiation
- **Performance:**
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:**
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:**
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:** 100% self sufficient, consumes 1/10 the heat and 1/5 the electricity of a "normal" house

Other Comments:

Thin metal dome 14'5" high by 31'6" in diameter with 3" of plastic foam insulation. Windows are 19 portholes (8½" diameter) and one skylight (6'1" in diameter) all single glazing. Light bulbs totaling 150 watts brighten house; television, hi-fi, kithchen blender.

(a) electrical storage in 16 high capacity storage batteries.

(b) calculated by R. Gray.

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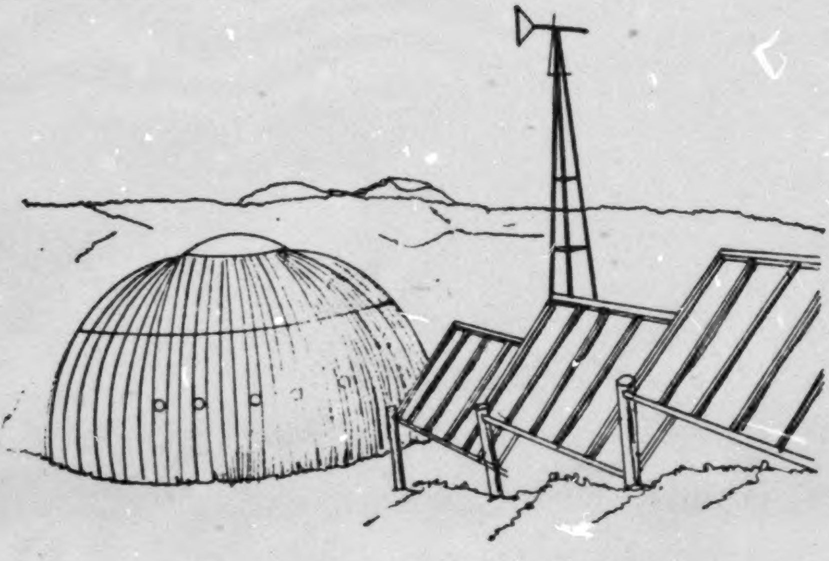

REINES' PROTOTYPE 1

4.11

Building name: Skytherm house
Author: Harold Hay; architects: K. Haggard and J. Edmisten
Date: September, 1973
Use of building: Residence
Duration of operation:
Location: Atascadero, Calif., 7983 Santa Rosa Road
    Latitude: 35°27'N
    Altitude: 1,000 ft.
    Normal degree-days/year: 2400 (Fresno)
    Ave. Jan. solar intensity on horizontal surface: 150 ly/Day
    Minimum design temperature: 25°F
    Ave. Jan. temperature: 48°F (san Francisco)
Building, floor area heated: 1,140 sqft.
    Number of heated levels: One storey, split level
    Windows:
    Walls:
    Roof:
    Indoor design temperature:
    Design (max.) heat load:
    Ave. Jan. heat load:
    Btu required per degree day:
    Total winter demand:
Collector, type, heat transfer fluid: Water in 20-mil pvc transparent bag, 10 inches deep(a,c)
    Position, orientation, tilt above horizontal: Horizontal, on roof
    Area: 1,216 sqft.
    Reflector, area and slope: None
    Type of heat transfer surface: Black plastic beneath transparent water bag
    Glazing: 20-mil pvc air bag on water bag, and 2" thick polyurthane foam movable insulation(b)
    Cost: Cost equal to furnace and air conditioner it replaces
    Freeze protection:
Storage, type: Water
    Volume: 7,000 gal.
    Weight: 58,600 lb.
    Water equivalent: Same
    Container: Plastic bags, metal roof deck, roof beams
    Heat capacity: 1.2 million Btu at 20°Δt
    Normal maximum temperature: 85°F
    Jan. storage in days: 4 days
Auxiliary energy supply, type: None has been installed
    Capacity:
    Mode of supply to system:
Heat collection and distribution:
    Transfer to storage: Storage in collector
    Motor requirement: Four 1/4 H.P. motors to open and close roof insulation; 4 min/day each
    Transfer to rooms: Radiant and conduction through metal roof deck, direct from collector
    Motor requirement: None (household fan for air movement if desired)
    Collector flow rate: None
    House flow rate: None
Hot water supply:
    Auxiliary heat:
    Solar source:
    Transfer means:
Automatic controls: Yes
    Collector and storage thermostats: Storage and "sol-air", 2°F difference activates
    Automatic control of auxiliary:
    Automatic valves and dampers:
    Heating direct from collector: Yes
    Automatic data recording: Yes, $40,000 HUD grant to Prof. Kenneth Haggard of Cal. Poly., San Louis D.
    Pyroheliometer on site:
Cooling: Yes, summer max. 110°F, mean 70°F
    Heat disposal method: Night sky radiation and convection
    Auxiliary cooling: None
    Power required: (Same 1/4 H.P. motors on insulation and house fan if desired)
    Heat removal from rooms: Radiant, direct to collector through metal roof deck
Performance:
    Period: September, 1973 on daily inside variation of 3°F, outdoor 30°Δt
    Ave. collector efficiency while operating:
    Ave. collector efficiency, total radiation:
    Total winter heat supply by solar:
    Auxiliary energy supply:
    Heat equivalent of auxiliary:
    Percent load supplied by solar:
    Expected (theoretical) performance:

Other comments:

(a) Hollow concrete block walls were filled with gont or water or sand to increase thermal mass, including internal partitions. South wall, 12" hollow concrete blocks with plastic tubes of water inside forms secondary collector, which likewise has moveable insulation. Possible thermosyphon loop all the way around room (ceiling-wall-floor)

(b) One layer tedlar could be installed above water bag in winter to improve collection to about 50%. 20-mil pvc air bag on top of water bag was used in this house.

(c) Because carpeting prevents floor slab from helping as thermal mass, roof pond was made 2" deeper than in Phoenix prototype.

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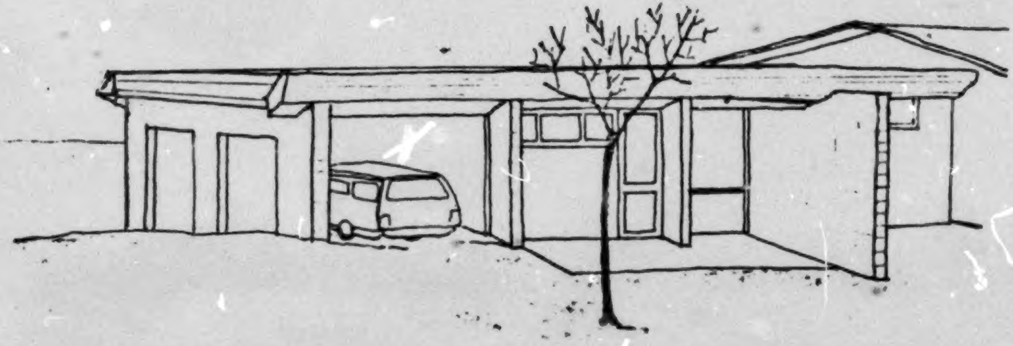

SKYTHERM HOUSE

4.12

Building name: Löf Office/Beckman Solar House
Author: Löf of Colorado State University; Beckman of University of Wisconsin[a]
Date: Constructed spring, 1974
Use of building: Laboratory/residence
Duration of operation:
Location: Fort Collins, Colorado
Latitude: Approx. 40°30'N
Altitude: Approx 5400 ft.
Normal degree-days/year: 6132 (Denver)
Ave. Jan. solar intensity on horizontal surface: 220 ly/day (used Albuquerque, N.M. data for analysis)
Minimum design temperature: 0°F
Ave. Jan. temperature: 29°F
Building, floor area heated: 1500 sqft.
Number of heated levels: 2
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Water with antifreeze
Position, orientation, tilt above horizontal: South roof, 45° tilt
Area: 780 sqft.
Reflector, area and slope: None
Type of heat transfer surface: Aluminum sheet with integral tubes
Glazing: Two layers glass, low reflection glass
Cost: Solar system, $10,000
Freeze protection: Antifreeze and draining
Storage, type: Water
Volume: 12,000 gal. (12.5 lb/sqft. collector)
Weight: 10,000 lb.
Water equivalent: Same
Container: Steel tank
Heat capacity: 650,000 Btu at 65°Δt[b]
Normal maximum temperature:
Jan. storage in days:
Auxiliary energy supply, type:
Capacity:
Mode of supply to system: Water heater to second coil in fan coil unit
Heat collection and distribution:
Transfer to storage: Heat exchanger from antifreeze in collector to water in storage
Motor requirement:
Transfer to rooms: Fan coil unit
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply: Pre-heat
Auxiliary heat: Gas fired hot water heater
Solar source: Yes
Transfer means: Pre-heat coil in main solar storage tank
Automatic controls: Full
Collector and storage thermostats: Collector and storage and room
Automatic control of auxiliary: Yes, room auxiliary thermostat 2°F below room solar temperature
Automatic valves and dampers:
Heating direct from collector: No
Automatic data recording: Yes
Pyrheliometer on site: Yes
Cooling: Solar driven lithium bromide absorption chiller
Heat disposal method: Water cooling tower, at 75°F
Auxiliary cooling:
Power required:
Heat removal from rooms: Fan coil unit
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 80% of heating and cooling supplied by solar

Other comments:

[a] Under a $200,000 NSF grant.

[b] Calculated by R. Gray.

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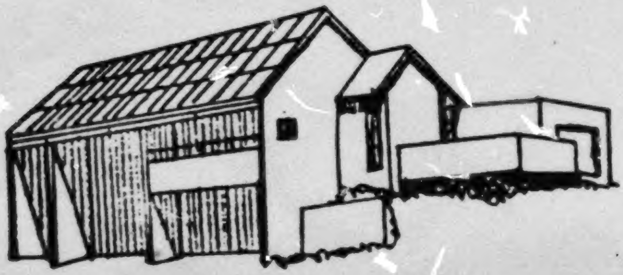

LOF OFFICE/BECKMAN SOLAR HOUSE

4.13

- **Building name:** House for Meditation Society
- **Author:** Nan Nalders et. al.
- **Date:** 1974-75
- **Use of building:** Residence and meetings
- **Duration of operation:** Existing building, solar added
- **Location:** In mountains near Santa Fe, New Mexico
  - **Latitude:** 36°N (Santa Fe)
  - **Altitude:** Above 7,000 ft. (Santa Fe)
  - **Normal degree-days/year:** 6120 (Santa Fe)
  - **Ave. Jan. solar intensity on horizontal surface:** 300 ly/Day
  - **Minimum design temperature:** 0°F (Santa Fe)
  - **Ave. Jan. temperature:** 30°F (Santa Fe)
- **Building, floor area heated:** 2,400 sqft.(a)
  - **Number of heated levels:**
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:**
  - **Design (max.) heat load:**
  - **Ave. Jan. heat load:**
  - **Btu required per degree day:**
  - **Total winter demand:**
- **Collector, type, heat transfer fluid:** Water-glycol
  - **Position, orientation, tilt above horizontal:** In a clearing separate from building
  - **Area:**
  - **Reflector, area and slope:**
  - **Type of heat transfer surface:** "Silastic" silicon rubber tubing bonded with "thermon" to galvanized steel plate.
  - **Glazing:**
  - **Cost:** $5.00/sqft. of collector for collector(b)
  - **Freeze protection:**
- **Storage, type:** Water storage
  - **Volume:** 6,000 gal.
  - **Weight:** 50,000 lb.
  - **Water equivalent:**
  - **Container:** Tank, urethane foam sprayed on outside, buried
  - **Heat capacity:** 3.25 million Btu(c)
  - **Normal maximum temperature:**
  - **Jan. storage in days:**
- **Auxiliary energy supply, type:** Windmills for pumps and lights, fireplace
  - **Capacity:**
  - **Mode of supply to system:**
- **Heat collection and distribution:**
  - **Transfer to storage:** Heat exchanger from collector to storage
  - **Motor requirement:** Pump
  - **Transfer to rooms:**
  - **Motor requirement:**
  - **Collector flow rate:**
  - **House flow rate:**
- **Hot water supply:** Yes
  - **Auxiliary heat:** None
  - **Solar source:** Collector and storage
  - **Transfer means:** Heat exchange coil in storage tank
- **Automatic controls:**
  - **Collector and storage thermostats:**
  - **Automatic control of auxiliary:**
  - **Automatic valves and dampers:**
  - **Heating direct from collector:**
  - **Automatic data recording:**
  - **Pyrohelioometer on site:**
- **Cooling:**
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:**
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:**
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:**
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:** Self sufficient on solar, wind, and firewood

Other Comments:

(a) Existing House with 9" adobe walls was insulated inside with 3" urethane foam and 1" adobe plaster.

(b) Complete system including windmills, electric wiring, controls, plumbing cost \$6.50/sq ft. of house or 15,6000.

(c) calculated by R. Gray at $\Delta t = 65^{\circ}$ F.

Bibliography

Talk by Nan Nadlers at Women's Design Conference, University of Oregon, May 1974.

4.14

Building name: Decade 80 Solar House
Author: Copper Developement Association, Architect A. Kotch
Date: 1975
Use of building: Residence
Duration of operation:
Location: Tucson, Arizona
    Latitude: 32° N
    Altitude: 2600 ft
    Normal degree-days/year: 1800
    Ave. Jan. solar intensity on horizontal surface: 315 ly/day
    Minimum design temperature: 30°F
    Ave. Jan. temperature: 42°
Building, floor area heated: 3200 ft^2
    Number of heated levels: one
    Windows:
    Walls:
    Roof:
    Indoor design temperature:
    Design (max.) heat load:
    Ave. Jan. heat load:
    Btu required per degree day:
    Total winter demand:
Collector, type, heat transfer fluid: water
    Position, orientation, tilt above horizontal: south facing, 27° slope (main) ; 40° slope
    (pool heater
    Area: 1800 ft^2 (main) + 400 ft^2 (pool)
    Reflector, area and slope: none (8in. O.C.)
    Type of heat transfer surface: rectangular/copper tubes, clipped to/copper sheet
    Glazing: doubling glass- PPG T-window on main collector; (.016 -#in)
    Cost: pool collector unglazed
    Freeze protection: water & ethylene glycol
Storage, type: water
    Volume: 2500 gallons
    Weight:
    Water equivalent:
    Container: 3000 gallon steel tank (8.5 ft. in diam., 8.5 ft. long)
    Heat capacity:
    Normal maximum temperature:
    Jan. storage in days: estimated 1-1½ days
Auxiliary energy supply, type:
    Capacity: 120,000 Btu/hr to 145° F water (170,000 Btu/hr to room Temp. water)
    Mode of supply to system: 60 gallon hot water heater
Heat collection and distribution:
    Transfer to storage: water and ethylene glycol
    Motor requirement:
    Transfer to rooms: water circulated to rooms
    Motor requirement:
    Collector flow rate: 20 gpm
    House flow rate:
Hot water supply: preheated
    Auxiliary heat:
    Solar source:
    Transfer means: heat exchange in storage tank
Automatic controls:
    Collector and storage thermostats: yes
    Automatic control of auxiliary: yes
    Automatic valves and dampers:
    Heating direct from collector: no
    Automatic data recording:
    Pyroheliometer on site:
Cooling: yes
    Heat disposal method: 2 Arkla-served Model 501 LiBr absorption-type (total output
    Auxiliary cooling: air-conditioning driven by 72,000 Btu/hr-6ton)
    Power required: auxiliary hot water heater
    Heat removal from rooms: forced air
Performance:
    Period:
    Ave. collector efficiency while operating:
    Ave. collector efficiency, total radiation:
    Total winter heat supply by solar:
    Auxiliary energy supply:
    Heat equivalent of auxiliary:
    Percent load supplied by solar:
    Expected (theoretical) performance:

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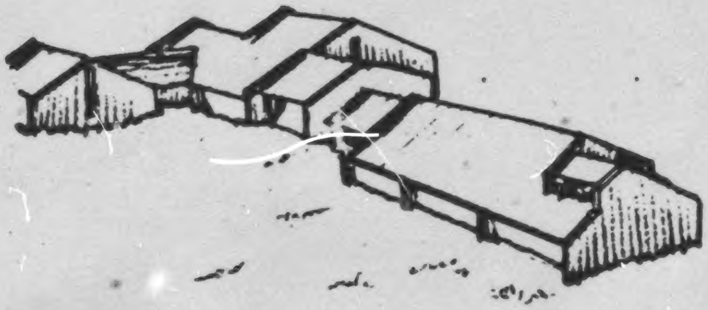

DECADE 80 SOLAR HOUSE

4.15

- **Building name:** CROWTHER SOLAR OFFICE BUILDING
- **Author:** R.L. Crowther
- **Date:** 1975 (estimate)
- **Use of building:** Office Building
- **Duration of operation:**
- **Location:** Denver Location
  - **Latitude:** 40^{o}N
  - **Altitude:** 5400 ft. Approx.
  - **Normal degree-days/year:** 6283
  - **Ave. Jan. solar intensity on horizontal surface:** 400 ly/Day
  - **Minimum design temperature:** -10^{o}F
  - **Ave. Jan. temperature:** 30^{o}F
- **Building, floor area heated:** 7000 ft.^{2}
  - **Number of heated levels:** 3
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:**
  - **Design (max.) heat load:**
  - **Ave. Jan. heat load:**
  - **Btu required per degree day:**
  - **Total winter demand:**
- **Collector, type, heat transfer fluid:** Flat plate, Air-type collector
  - **Position, orientation, tilt above horizontal:** South facing, 53 slope from horizontal
  - **Area:** 600 ft.^{2}
  - **Reflector, area and slope:**
  - **Type of heat transfer surface:**
  - **Glazing:** Double glazed, tempered glass
  - **Cost:**
  - **Freeze protection:**
- **Storage, type:** Water
  - **Volume:** 4000 gal.
  - **Weight:**
  - **Water equivalent:**
  - **Container:** 2 insulated, concrete tanks in basement
  - **Heat capacity:**
  - **Normal maximum temperature:**
  - **Jan. storage in days:**
- **Auxiliary energy supply, type:**
  - **Capacity:**
  - **Mode of supply to system:**
- **Heat collection and distribution:**
  - **Transfer to storage:**
  - **Motor requirement:**
  - **Transfer to rooms:**
  - **Motor requirement:**
  - **Collector flow rate:**
  - **House flow rate:**
- **Hot water supply:**
  - **Auxiliary heat:**
  - **Solar source:**
  - **Transfer means:**
- **Automatic controls:**
  - **Collector and storage thermostats:**
  - **Automatic control of auxiliary:**
  - **Automatic valves and dampers:**
  - **Heating direct from collector:**
  - **Automatic data recording:**
  - **Pyroheliometer on site:**
- **Cooling:**
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:**
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:**
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:**
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:** 80%

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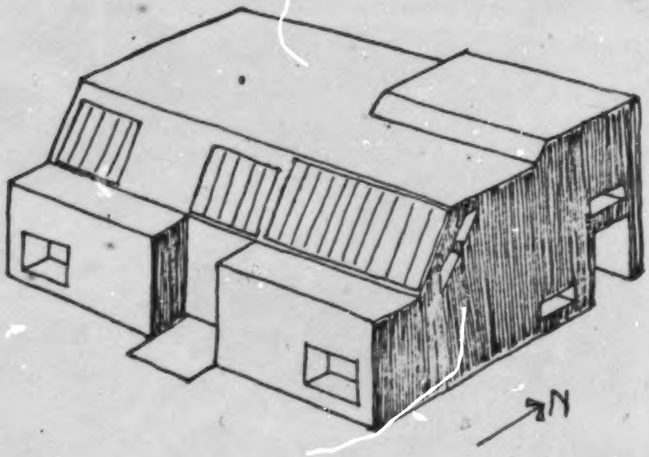

CROWTHER OFFICE BUILDING

4.16

Building name: CROWTHER HOUSE
Author: R.L. Crowther
Date: July 1975
Use of building: Residence
Duration of operation:
Location: Denver, Colorado
Latitude: 40°N
Altitude: 5400 ft Approx.
Normal degree-days/year: 6283
Ave. Jan. solar intensity on horizontal surface: 400 ly/Day
Minimum design temperature: -10°F
Ave. Jan. temperature: 30°F
Building, floor area heated: 800 ft^2 and 200 ft^2 loft
Number of heated levels: 2
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Flat plate, Air-type
Position, orientation, tilt above horizontal: South Facing, 50°from horizontal
Area: 200 ft^2
Reflector, area and slope:
Type of heat transfer surface: Galv. steel with non-selective black coating
Glazing: Double Glazed with double-strength window glass
Cost: $3500
Freeze protection:
Storage, type: 12 tons, 1 in. Dia. Rocks
Volume: 234 Cu. ft.
Weight: 12 tons
Water equivalent:
Container: Rectangular Plywood Bin with 6" fiberglass insulation
Heat capacity:
Normal maximum temperature:
Jan. storage in days:
Auxiliary energy supply, type: Radiant Electrical Heat
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: Circulating Air to Rocks
Motor requirement:
Transfer to rooms: Air circulating through rocks
Motor requirement: Blower, 3/4 HP
Collector flow rate: 400 cfm
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source: Hot-Air from collector
Transfer means: Heat exchanger
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling:
Heat disposal method: Night convection through bin
Auxiliary cooling:
Power required:
Heat removal from rooms: House air through bin assisted by 'Solar Heated Chimney'
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 85%

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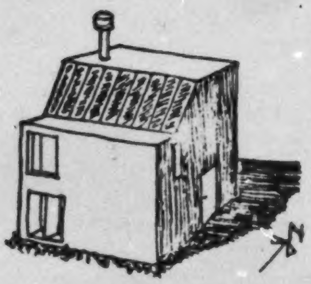

CROWTHER HOUSE

4.17

Building name: CHERRY CREEK SOLAR RESIDENCE B
Author: R.L. Crowther
Date: October, 1974
Use of building: Residence
Duration of operation:
Location: Denver, Colorado
Latitude: 40°N
Altitude: 5400 ft. Approx.
Normal degree-days/year: 6283
Ave. Jan. solar intensity on horizontal surface: 400 ly/Day
Minimum design temperature: -10°F
Ave. Jan. temperature: 30°F
Building, floor area heated: 1100 ft^2
Number of heated levels: 2
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Flat plate, Air-type by Solaron Corp.
Position, orientation, tilt above horizontal: South facing 53° from Horizontal
Area: 380 ft^2
Reflector, area and slope:
Type of heat transfer surface:
Glazing: Double-glazed 1/8" glass
Cost:
Freeze protection:
Storage, type: Rock
Volume: 20 cubic yards-3/4" to 1 1/2" Diameter rocks
Weight:
Water equivalent:
Container: converted old coal bin (insulated)
Heat capacity:
Normal maximum temperature:
Jan. storage in days:
Auxiliary energy supply, type: Gas Furnace
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage:
Motor requirement:
Transfer to rooms:
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling:
Heat disposal method: Night time Gravity Convection
Auxiliary cooling:
Power required:
Heat removal from rooms: Convection of cool air
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 85%

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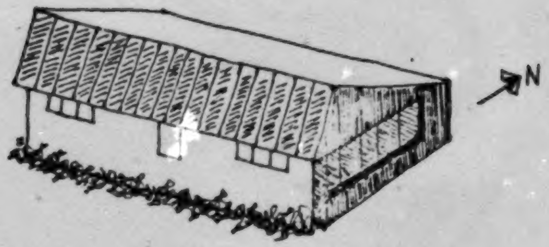

CHERRY CREEK SOLAR RESIDENCE B

Building name: CHERRY CREEK SOLAR RESIDENCE A
Author: R.L. Crowther
Date: 1974-75
Use of building: Residence
Duration of operation:
Location: Denver, Colorado
  Latitude: 40°N
  Altitude: 5400 ft Approx.
  Normal degree-days/year: 6283
  Ave. Jan. solar intensity on horizontal surface: 400 ly/Day
  Minimum design temperature: -10°F
  Ave. Jan. temperature: 30°F
Building, floor area heated:
  Number of heated levels: 3
  Windows:
  Walls:
  Roof:
  Indoor design temperature:
  Design (max.) heat load:
  Ave. Jan. heat load:
  Btu required per degree day:
  Total winter demand:
Collector, type, heat transfer fluid: 3 separate collectors; 2 flat plate, water-type
  Position, orientation, tilt above horizontal: Main collector 53°,South wall vertical, greenhouse 30°
  Area: Main-560 ft^2, South wall-40 ft^2, Greenhouse 150 ft^2.
  Reflector, area and slope:
  Type of heat transfer surface: Aluminum plate
  Glazing: Double glazed with tempered glass
  Cost:
  Freeze protection: System drainage
Storage, type: Main-water
  Volume: 1000 gal.
  Weight:
  Water equivalent:
  Container: Cylindrical (4 ft. Dia. x 12 ft High) Fiberglass tank
  Heat capacity:
  Normal maximum temperature:
  Jan. storage in days:
Auxiliary energy supply, type: Gas furnace
  Capacity:
  Mode of supply to system:
Heat collection and distribution:
  Transfer to storage:
  Motor requirement:
  Transfer to rooms:
  Motor requirement:
  Collector flow rate:
  House flow rate:
Hot water supply:
  Auxiliary heat:
  Solar source:
  Transfer means:
Automatic controls:
  Collector and storage thermostats:
  Automatic control of auxiliary:
  Automatic valves and dampers:
  Heating direct from collector:
  Automatic data recording:
  Pyroheliometer on site:
Cooling:
  Heat disposal method: Convection through vertical duct extending to roof
  Auxiliary cooling: Cool air from 5400 cfm evaporative cooler on North roof
  Power required:
  Heat removal from rooms:
Performance:
  Period:
  Ave. collector efficiency while operating:
  Ave. collector efficiency, total radiation:
  Total winter heat supply by solar:
  Auxiliary energy supply:
  Heat equivalent of auxiliary:
  Percent load supplied by solar:
  Expected (theoretical) performance: 90%

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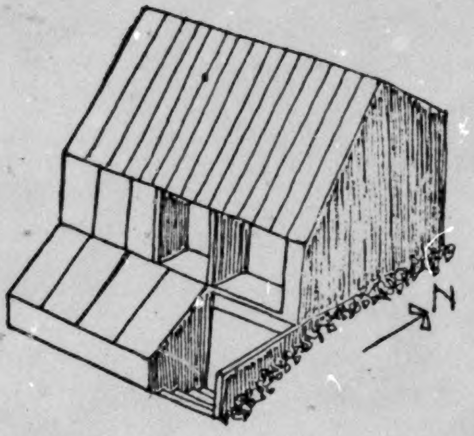


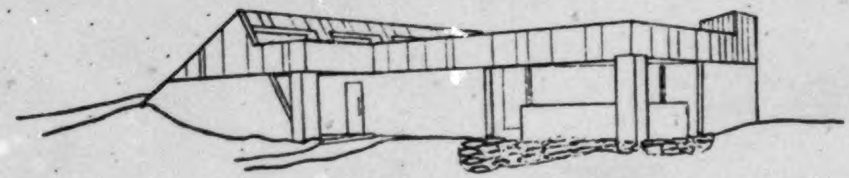
CHERRY CREEK SOLAR RESIDENCE A

4.19

Building name: CASA DEL SOL OF THE FUTURE
Author: R.L. San Martin
Date:
Use of building: Residence - Lab
Duration of operation:
Location: Las Cruces, New Mexico
Latitude: 32.3°N
Altitude: 5000 ft.
Normal degree-days/year: 3000
Ave. Jan. solar intensity on horizontal surface: 320 ly/Day
Minimum design temperature: 15°
Ave. Jan. temperature: 42°
Building, floor area heated: 1950 sq. ft.
Number of heated levels: 1
Windows: Double glazed
Walls: 2 inch polyuethene foam
Roof: 3 inch polyuethene foam
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Revere copper, water
Position, orientation, tilt above horizontal:
Area: 800 sq. ft.
Reflector, area and slope:
Type of heat transfer surface: Enthone selective surface
Glazing: Double
Cost:
Freeze protection:
Storage, type: Steel
Volume: 2000 gal.
Weight:
Water equivalent:
Container: Steel, epoxy coated, 50 psi, 3 1/2" polyurethene foam
Heat capacity
Normal maximum temperature:
Jan. storage in days:
Auxiliary energy supply, type: water boiler
Capacity: 52 gal, input 32 KW, output 109,216 Btuh
Mode of supply to system: direct
Heat collection and distribution:
Transfer to storage: Water-water heat exchange
Motor requirement:
Transfer to rooms: Water-air heat exchange
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling: Arkla 3 ton (Libr-water)
Heat disposal method: cooling tower 5 ton
Auxiliary cooling:
Power required: Water fired
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance:

Bibliography

Personal Correspondence



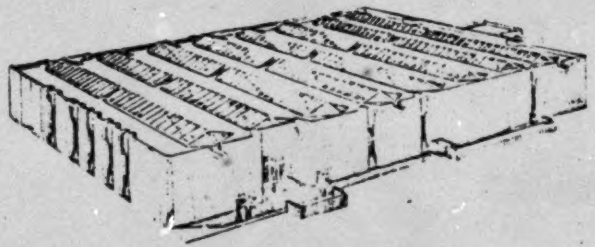
CASA DEL SOL OF THE FUTURE

4.20

Building name: NEW MEXICO DEPARTMENT OF AGRICULTURE
Author: R.L. San Martin
Date: 11/12/75
Use of building: Agriculture Department
Duration of operation:
Location: Las Cruces, New Mexico
Latitude: 32.3°N
Altitude: 5000 ft.
Normal degree-days/year: 3000
Ave. Jan. solar intensity on horizontal surface: 320 ly/Day
Minimum design temperature: 15°
Ave. Jan. temperature: 42°
Building, floor area heated: 25,500 sq. ft.
Number of heated levels: 1
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Flat plate (sunsource), 10:1 (Northrup) concentrator, water & glycol
Position, orientation, tilt above horizontal: 30°South
Area: Flat plate 6,190 sq. ft. , 540 sq. ft. concentrator
Reflector, area and slope:
Type of heat transfer surface: Flat plate Tabor selective surface a= .92 e= .096
Glazing: Concentrator Copper oxide selective surface a= .9 e= .2
Cost:
Freeze protection: glycol
Storage, type: Water
Volume: 2 x 15,000 gal 30 psi
Weight:
Water equivalent:
Container: steel epoxy coated, 3.5" polyurethene exterior coating
Heat capacity:
Normal maximum temperature:
Jan. storage in days: 3
Auxiliary energy supply, type: Gas fired boiler, mainly for cooling
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: Water-glycol hear exchange
Motor requirement:
Transfer to rooms: Water-air heat exchange
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling: Absorption refrigeration system, York 100 ton & Arkla 25 ton (Libr-Water)
Heat disposal method:
Auxiliary cooling:
Power required: Water fired
Heat removal from rooms: Heat exchanger recovers energy from exhaust air
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 100%

Bibliography

Personal Correspondence



NEW MEXICO DEPARTMENT OF AGRICULTURE

4.21

- Building name: CARR HOUSE
- Author: L.H. Carr
- Date: 11/15/75
- Use of building: Residence
- Duration of operation: Retrofit of Solar heat in Summer 1973
- Location: San Luis Obispo, California
  - Latitude: 35½°N
  - Altitude: 100 ft.
  - Normal degree-days/year: 2500
  - Ave. Jan. solar intensity on horizontal surface: 271 ly/Day
  - Minimum design temperature: 32°F
  - Ave. Jan. temperature: 45°F
- Building, floor area heated: 1600 sqft.
  - Number of heated levels: 1
  - Windows: 300 sqft.
  - Walls: 1540 sqft.
  - Roof: 1600 sqft.
  - Indoor design temperature: 70°F
  - Design (max.) heat load: 22,200 BTU/H
  - Ave. Jan. heat load: 14,600 BTU/H
  - Btu required per degree day: 14,000 BTU
  - Total winter demand: 35,000,000 BTU
- Collector, type, heat transfer fluid: Water
  - Position, orientation, tilt above horizontal: South, 30°
  - Area: 720 sqft.
  - Reflector, area and slope: None
  - Type of heat transfer surface: Polyethylene pipe, ½ in., 3000 ft.
  - Glazing: Clear 6 Mil Polyethylene
  - Cost: $700
  - Freeze protection: None
- Storage, type: Concrete Floor Slab
  - Volume: 800 Cuft.
  - Weight: 125 tons
  - Water equivalent: 6000 gal.
  - Container: None
  - Heat capacity: 50,000 BTU/°F
  - Normal maximum temperature: 80°F
  - Jan. storage in days: 2 Day
- Auxiliary energy supply, type: Propane Fired Hot Water Heater
  - Capacity: 60,000 BTU/hr
  - Mode of supply to system:
- Heat collection and distribution:
  - Transfer to storage: Water Pump
  - Motor requirement: ½ H.P.
  - Transfer to rooms: Radiation from Floor Slab
  - Motor requirement: None
  - Collector flow rate: 9 gpm.
  - House flow rate: 9 gpm.
- Hot water supply: 80 sqft. Solar Collector
  - Auxiliary heat: Electric Resistance
  - Solar source: Like House Collector, 600 ft. ½ in. pipe
  - Transfer means: 1/20 H.P. Pump
- Automatic controls:
  - Collector and storage thermostats: Collector Pump on at 110°F
  - Automatic control of auxiliary: Timer and Room thermostat
  - Automatic valves and dampers: None
  - Heating direct from collector: Yes
  - Automatic data recording: None
  - Pyroheliometer on site: None
- Cooling: None
  - Heat disposal method:
  - Auxiliary cooling:
  - Power required:
  - Heat removal from rooms:
- Performance:
  - Period: Summer 1973 To Present
  - Ave. collector efficiency while operating:
  - Ave. collector efficiency, total radiation:
  - Total winter heat supply by solar: 28,000,000 BTU
  - Auxiliary energy supply: 200 gal. Propane
  - Heat equivalent of auxiliary: 8,750,000 BTU
  - Percent load supplied by solar: 80%
  - Expected (theoretical) performance:

Bibliography

Personal Correspondence

4.22

Building name: SOLAR & SON
Author: Richard Cottrell
Date:
Use of building: Residence
Duration of operation: 12 Mo./yr
Location: Visalia, California
Latitude: 36.2°
Altitude: 330 ft.
Normal degree-days/year: 2500
Ave. Jan. solar intensity on horizontal surface: 175 ly/Day
Minimum design temperature: 40°
Ave. Jan. temperature: 45°
Building, floor area heated:
Number of heated levels: 2
Windows: 22 lites 46" x 76" Thermal insul. glass
Walls:
Roof:
Indoor design temperature: 65°- 80°
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Parabolic trough - water w/ anti-freeze
Position, orientation, tilt above horizontal: 15°
Area: 400 sq. ft.
Reflector, area and slope:
Type of heat transfer surface: Aluminum, black anodized coating
Glazing: None
Cost: Classified
Freeze protection: Anti-freeze
Storage, type:
Volume: 8000 gal.
Weight:
Water equivalent:
Container: conc. block underground
Heat capacity:
Normal maximum temperature: max. 200°F
Jan. storage in days: 21 days
Auxiliary energy supply, type: One 30" Franklin Cast Iron fireplace with exposed single thickness stack in
Capacity: Linen Room, and large antique pot belly stove in master bedroom.
Mode of supply to system: Convection or hot air rising may be mechanically taken by overhead returns.
Heat collection and distribution:
Transfer to storage: Direct
Motor requirement: ½ HP
Transfer to rooms: Put through air handler system to underfloor perimeter registers.
Motor requirement: ½ HP
Collector flow rate: 7.5 gal/min
House flow rate:
Hot water supply:
Auxiliary heat: Coil in stack of pot belly prior to W.H.
Solar source: Parabolic collectors and coil to W.H. suspended in H.W. storage
Transfer means: Fluid connection
Automatic controls:
Collector and storage thermostats: Honeywell
Automatic control of auxiliary: None---Build fire
Automatic valves and dampers: For outside air
Heating direct from collector:
Automatic data recording: None
Pyroheliometer on site: None
Cooling:
Heat disposal method: Into irrigation water going to sprinkler system to irrigate 8 acres of walnuts
Auxiliary cooling:
Power required: Fan only ½ HP
Heat removal from rooms: Perimeter supply & overhead return 2,000 cfm---3-5 ton chiller coils with 60°F well water kept 1760 sq. ft. house @ 76°Max. on 108° day. Provided 65°air from 62° water.
Performance:
Period: Summer 1975
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar: 75%
Auxiliary energy supply: 20%
Heat equivalent of auxiliary: as above as required
Percent load supplied by solar: 80%
Expected (theoretical) performance: 80% or better

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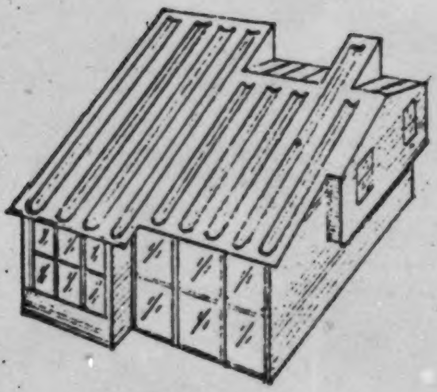

SOLAR & SON

Building name: VAN DRESSER RESIDENCE
Author: Peter Van Dresser
Date: 1958
Use of building: Residence
Duration of operation: to present
Location: Santa Fe, New Mexico
Latitude: 35.6°
Altitude: 7000 ft.
Normal degree-days/year: 6120
Ave. Jan. solar intensity on horizontal surface: 300 ly/Day Approx.
Minimum design temperature: 5°
Ave. Jan. temperature: 20°
Building, floor area heated: 500 sq ft.
Number of heated levels: 1
Windows:
Walls: Adobe
Roof:
Indoor design temperature: 68°
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Air
Position, orientation, tilt above horizontal: South; 45°
Area: 250 sq ft.
Reflector, area and slope: None
Type of heat transfer surface: Sheet metal
Glazing: Single
Cost:
Freeze protection: None
Storage, type: Rock, Sand
Volume: 352 Cu. Ft. Sand, 592 Cu. Ft. Rock
Weight: 94,000 lbs.
Water equivalent: 2,246.6 gal.
Container: Ground
Heat capacity: 49,412 BTU
Normal maximum temperature: 150° inlet
Jan. storage in days:
Auxiliary energy supply, type: Gas
Capacity: 12,000 BTU
Mode of supply to system:
Heat collection and distribution: Passive
Transfer to storage: BTU Watt Fan
Motor requirement:
Transfer to rooms: conduction
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply: Solar
Auxiliary heat: Electric resistance
Solar source: Sun
Transfer means: Air to water coil
Automatic controls:
Collector and storage thermostats: differential at 12°
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector: Yes
Automatic data recording:
Pyroheliometer on site:
Cooling: None
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance:

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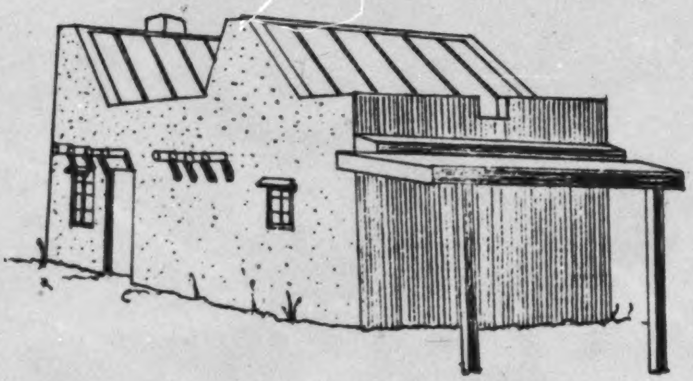

VAN DRESSER RESIDENCE

4.24

Building name: ENGLE RESIDENCE
Author: Alan Lower, Architect...3535 N.W. 58th, Oklahoma City, Okla. 73112
Date: Completed December, 1975
Use of building: Residence
Duration of operation:
Location: Wagoner, Oklahoma
Latitude: 35°
Altitude: 1100 ft.
Normal degree-days/year: 3725
Ave. Jan. solar intensity on horizontal surface: 360 ly/Day
Minimum design temperature: 0°
Ave. Jan. temperature: 48"
Building, floor area heated: 2800 Sq. ft.
Number of heated levels: 4
Windows: Dual glazed
Walls: 6" studs w/fiberglass batt
Roof: 6" fiberglass batt
Indoor design temperature: 70°
Design (max.) heat load: 60,000 BTU/HR
Ave. Jan. heat load: 18,900 BTU/HR
Btu required per degree day: 20,568 BTU
Total winter demand: 76,615,800 BTU
Collector, type, heat transfer fluid: Dual glazed, aluminum fin w/copper waterways, water
Position, orientation, tilt above horizontal: South-facing, 50°
Area: 470 sq. ft.
Reflector, area and slope: None
Type of heat transfer surface: Non-Selective, 'Nextel' coated aluminum
Glazing: Dual-insulated ¼" tempered glass (patio door size)
Cost: $10.00/ square foot
Freeze protection: Self draining
Storage, type: Water
Volume: 2000 gallon with partition; 800 gallon summer/ full 2000 gallon winter
Weight: 16,720 lbs.
Water equivalent:
Container: Concrete tank w/3" foamglass insulation on interior and fiberglass lined
Heat capacity: 1,337,600 BTU
Normal maximum temperature: 150° winter/ higher in summer by reducing volume
Jan. storage in days: 2 +
Auxiliary energy supply, type: Electric boiler; gas not available
Capacity: 16 KW in 4 KW steps
Mode of supply to system: Hot water to fan coil
Heat collection and distribution:
Transfer to storage: Water
Motor requirement: 1/3 HP pump
Transfer to rooms: Air
Motor requirement: 1 HP fan
Collector flow rate: 20 gpm max.
House flow rate: 1900 cfm
Hot water supply:
Auxiliary heat: Electric
Solar source: Collector
Transfer means: Heat exchanger in storage tank
Automatic controls:
Collector and storage thermostats: Differential themostat
Automatic control of auxiliary: Yes
Automatic valves and dampers: Yes
Heating direct from collector: Yes
Automatic data recording: None at present
Pyroheliometer on site: No
Cooling: Lithium bromide absorption chiller; 36,000 BTU capacity
Heat disposal method: Cooling tower
Auxiliary cooling: Enthalpy control and "economizer" -type outside air intake
Power required: Solar panels
Heat removal from rooms: Forced air
Performance: Presently being monitored
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 80%

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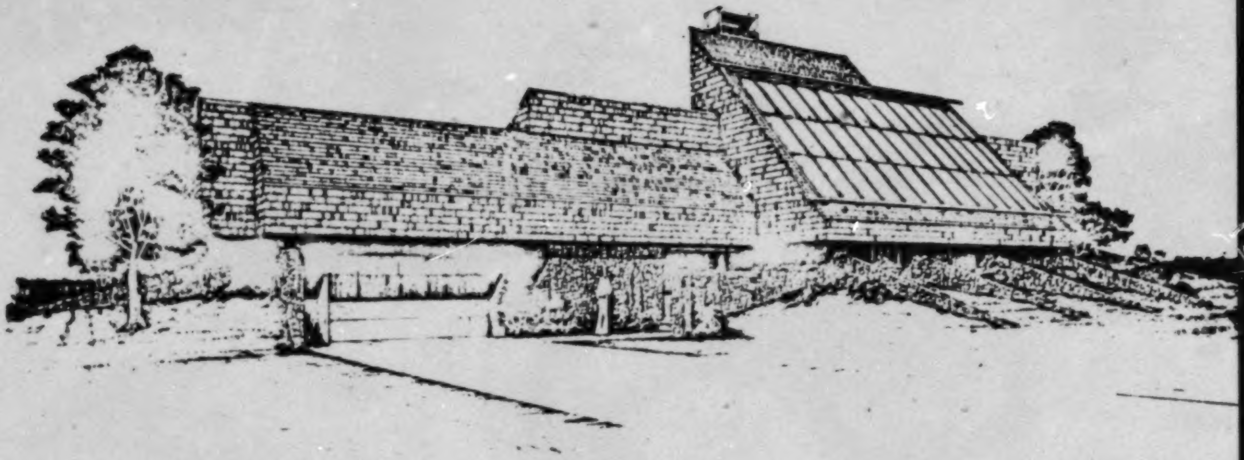

ENGLE RESIDENCE

Building name: MOLEN RESIDENCE
Author: Ronald L. Molen
Date: 1976
Use of building: Residence
Duration of operation: Under construction
Location: Salt Lake City, Utah
Latitude: 40°N
Altitude: 4500 ft. Approx.
Normal degree-days/year: 2052
Ave. Jan. solar intensity on horizontal surface: 380 ly/day
Minimum design temperature: 0°F
Ave. Jan. temperature: 20°F
Building, floor area heated:
Number of heated levels: 2
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Hot Air
Position, orientation, tilt above horizontal: 10° West of South at 57° from horizontal
Area:
Reflector, area and slope: None
Type of heat transfer surface: Black galv. steel
Glazing: Double glazing
Cost: $1500.00
Freeze protection: None
Storage, type: Rock
Volume:
Weight:
Water equivalent:
Container:
Heat capacity:
Normal maximum temperature:
Jan. storage in days:
Auxiliary energy supply, type:
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage:
Motor requirement:
Transfer to rooms:
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling:
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance:

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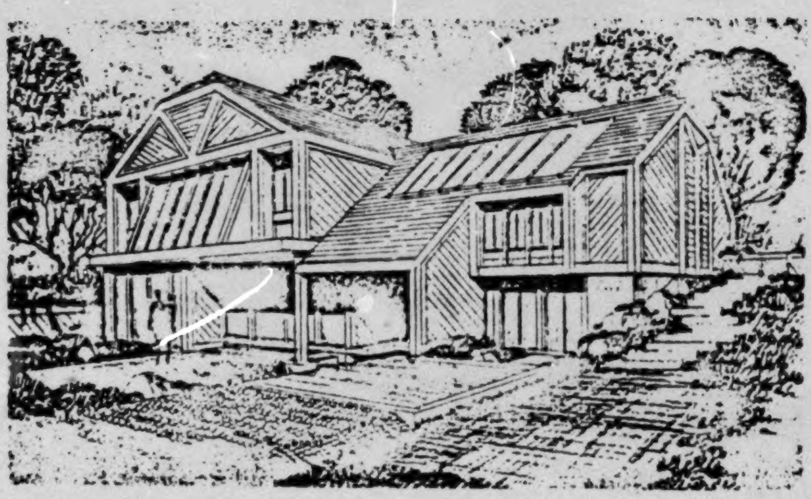
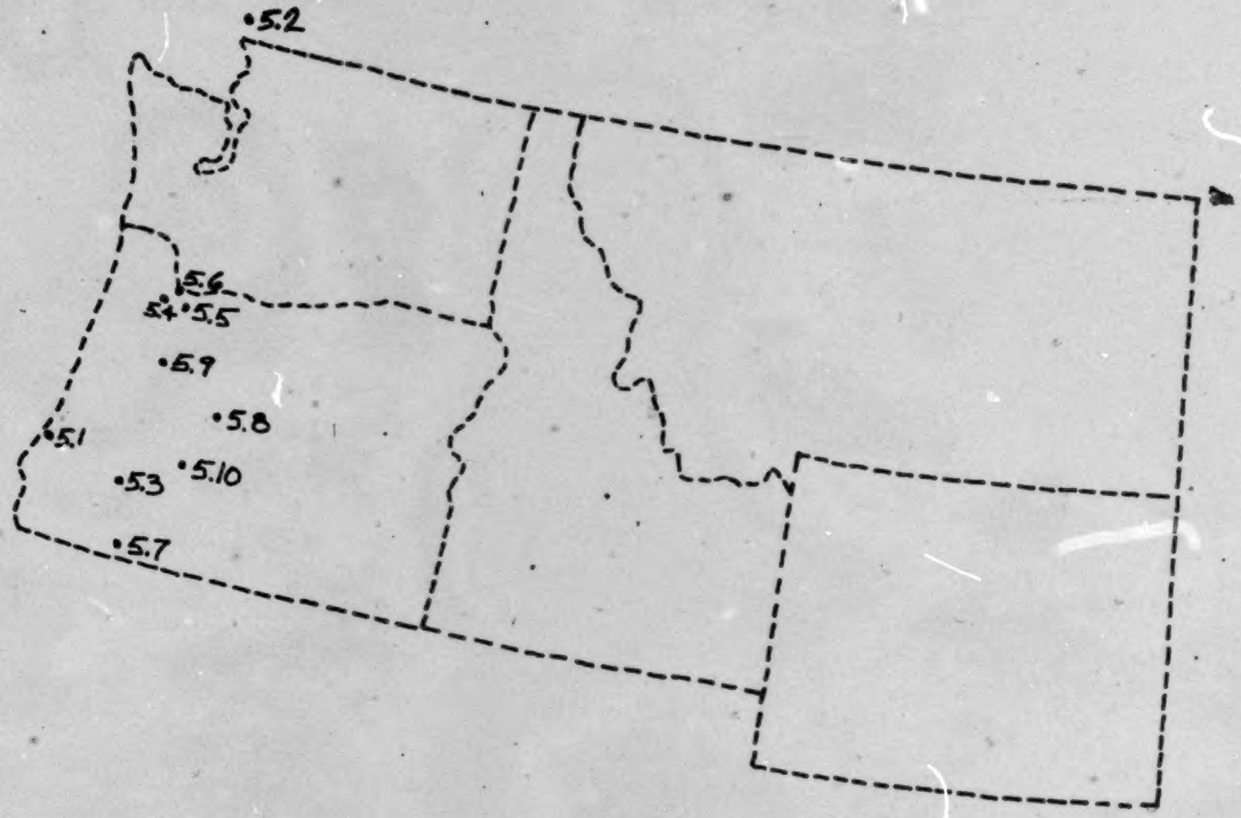
"Architect Tries Solar Heat", Salt Lake Tribune, September 28, 1975.



MOLEN RESIDENCE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NORTHWEST

5.1

Building name: Mathew Solar House
Author: Henry Mathew
Date: 1967 (solar collection started January, 1968)
Use of building: Residence of Henry Mathew
Duration of operation: 1968 to present
Location: Coos Bay, Oregon
    Latitude: 43°N
    Altitude: Approx. 50 ft.
    Normal degree-days/year: 4287 (c)
    Ave. Jan. solar intensity on horizontal surface: Not known (102 ly/day in Corvallis, Oregon)
    Minimum design temperature: +20°F
    Ave. Jan. temperature: 44.6°F
Building, floor area heated: 1,550 sqft.
    Number of heated levels: One
    Windows:
    Walls:
    Roof:
    Indoor design temperature: 70°F (thermostat 75°, 10:00 AM to 10:00 PM, off at night)
    Design (max.) heat load: 40,020 Btuh at Δt = 50°F
    Ave. Jan. heat load: 20,300 Btuh
    Btu required per degree day: 19,200 Btu
    Total winter demand: 50,000,000 Btu (d)
Collector, type, heat transfer fluid: Water heating
    Position, orientation, tilt above horizontal: On roof, facing south, 82° tilt
    Area: 400 sqft (secondary collector in yard, 325 sqft., tied in 1974)
    Reflector, area and slope: Yes, 2,000 sqft., 8° slope, adds 37.5%(a) more collection October - May
    Type of heat transfer surface: 1/2" galvanized steel pipes 4" o.c., on aluminum backing
    Glazing: Single glass
    Cost: $1,000 on materials, whole system
    Freeze protection: Drain collector whenever not collecting
Storage, type: Water
    Volume: 8,000 gal.
    Weight: 66,800 lb.
    Water equivalent: Same
    Container: Steel tank
    Heat capacity: 4,350,000 Btu at 65°Δt
    Normal maximum temperature: 140°F in October
    Jan. storage in days: 9 days
Auxiliary energy supply, type: Yes, portable resistance electric heaters
    Capacity: Full load
    Mode of supply to system: Used as needed
Heat collection and distribution:
    Transfer to storage: Store hot water
    Motor requirement: 1/3 H.P. pump (400 watts)
    Transfer to rooms: Convection of air from around tank
    Motor requirement: None
    Collector flow rate: 6.63 gpm (against 28' of water head, mostly friction)
    House flow rate: Unknown, varies
Hot water supply: Preheat
    Auxiliary heat: Electric
    Solar source: Hot water from collector
    Transfer means: Coil in storage tank
Automatic controls: Full
    Collector and storage thermostats: Mock collector and room
    Automatic control of auxiliary: Manual or unit thermostat
    Automatic valves and dampers: Two automatic dampers on air convection ducts
    Heating direct from collector: No
    Automatic data recording: Since January, 1974
    Pyroheliometer on site: Since May, 1974
Cooling: None, heating required year round(c)
    Heat disposal method:
    Auxiliary cooling:
    Power required:
    Heat removal from rooms:
Performance:
    Period: 1970 - 1973
    Ave. collector efficiency while operating:
    Ave. collector efficiency, total radiation: 36.5%
    Total winter heat supply by solar: 43,000,000 Btu
    Auxiliary energy supply: Electricity 2,215 KWh
    Heat equivalent of auxiliary: 7,560,000 Btu(b)
    Percent load supplied by solar: 85% (1974-5)
    Expected (theoretical) performance:

Other Comments:

(a) Efficiency of 30% is estimated from comparison with other solar house, solar radiation data for Corvallis, Oregon is used, and equivalant electric consumption for both heating and non-heating is estimated from comparisons with other Averages for Coos Bay and Oregon residents. A more accurate analysis is in progress.

(b) hydro electic source

(c) 80% of the annual heating degree days occur from mid-October through the end of May. It is assumed that summer Heating is supplied by solar gain, occupants, lighting, etc.

(d) Total Winter heat loss (Sept.-April) was 83,000,000 BTU, of which 33,000,000 BTU was supplied by Solar gain, occupants, lighting and appliances.

Bibliography

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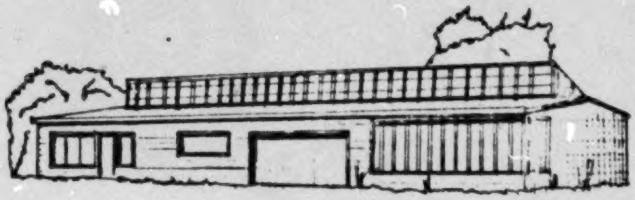


MATHEW SOLAR HOUSE

5.2

Building name: Hoffman Residence
Author: Eric Hoffman
Date: house constructed in 1968, collector completed in 1971, was in original design
Use of building: residence
Duration of operation: 1971 to present
Location: Vancouver, B. C., Canada
Latitude: 49° N
Altitude: 175 ft.
Normal degree-days/year: 5500
Ave. Jan. solar intensity on horizontal surface: 80 ly/Day
Minimum design temperature: + 10° F.
Ave. Jan. temperature: 37.2° F, varies from 21° to 42° F)
Building, floor area heated: 1500 s.f. main floor fully heated, 1300 s.f. basement partially heated
Number of heated levels: 1, plus basement
Windows: all double glazed
Walls: wood frame, 4'fiberglass insulation, full weather stripping
Roof: wood frame, 6" fiberglass insulation
Indoor design temperature: 70° F
Design (max.) heat load: 56,300 Btu H (a)
Ave. Jan. heat load: 30,6000 Btu H (b)
Btu required per degree day: 22,400 Btu (b)
Total winter demand: 123 x 10^6 Btu (b)
Collector, type, heat transfer fluid: water
Position, orientation, tilt above horizontal: on A-frame roof, facing due south, (58° tilt)
Area 400 sq.ft. net (not including mullions,frame, etc.)
Reflector, area and slope: none
Type of heat transfer surface: .005 inch copper soldered to ¼ copper tubes, painted flat black
Glazing: 2 layers glass at 3/4 inch spacing
Cost: $1500 for materials for whole system, constructed by Eric Hoffman
Freeze protection: drain collector, sealed system
Storage, type: water
Volume: 800 U. S. gallons
Weight: 6688 lb. (b)
Water equivalent:
Container: one 300 gal. and one 500 gal. salvaged boiler tanks, smaller tank is 5° to 10° hotter.
Heat capacity: 435,000 Btu (c)
Normal maximum temperature: 140° (c)
Jan. storage in days: 0.6 days (d)
Auxiliary energy supply, type: electirc resistance
Capacity: 16 KW
Mode of supply to system: baseboard convectors
Heat collection and distribution:
Transfer to storage: water pump
Motor requirement: 1/3 HP
Transfer to rooms: air convection (e)
Motor requirement:
Collector flow rate: 20 gpm
House flow rate:
Hot water supply: yes
Auxiliary heat: electric
Solar source: main collector
Transfer means:
Automatic controls:
Collector and storage thermostats: yes
Automatic control of auxiliary: yes
Automatic valves and dampers: manual
Heating direct from collector: none
Automatic data recording: some
Pyroheliometer on site: no
Cooling: none
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar: 50 % of all year round heat needs, 100% of domestic hot water during summer
Expected (theoretical) performance:

Other Comments:

(a) Eric Hoffman estimated 16 KW at 15° F and the local utility estimated 14 KW at 15° F. R. Gray converted this estimate to 56,000 BtuH at 10° F outside and 70° F inside.

(b) Calculated by R. Gray as described in Calculation Methods

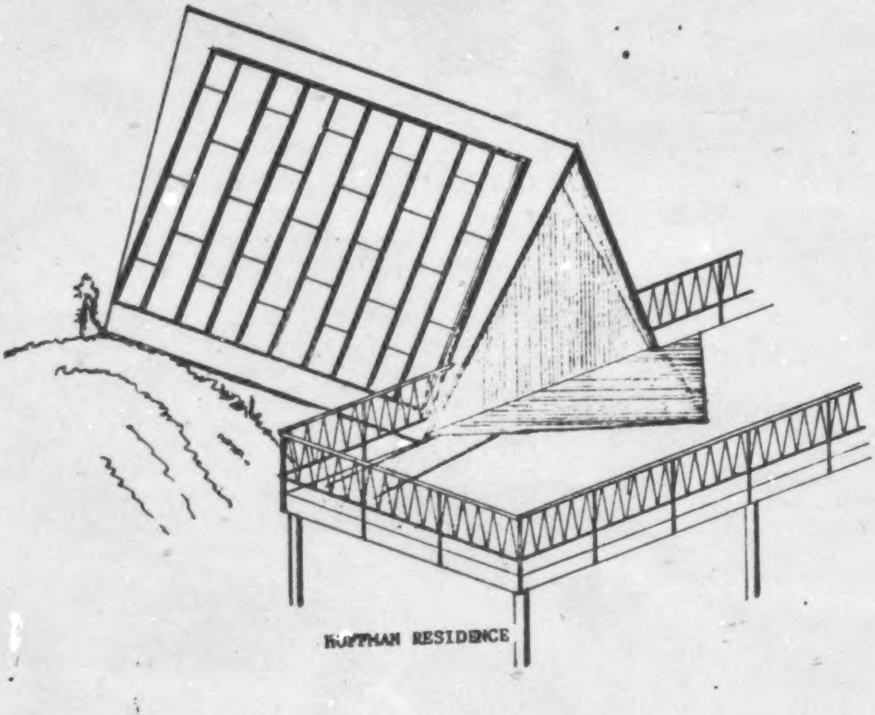
(c) According to Eric Hoffman, the storage tank remains at 170° F all summer and is normally heated to 130° F or 140° F during the winter. The storage can be used down to 60° F to preheat domestic water. However R. Gray used a 65° F. temperature difference to calculate storage capacity.

(d) Estimated by R. Gray. Eric Hoffman estimates one day of storage.

(e) Hot air is delivered to the house by opening the door to the storage tank room in the basement and allowing the hot air to rise up the stair well to the main floor. In the future, an air distribution system and a thermostatically controlled ¼ hp fan will be installed.

Bibliography

Eric Hoffamn was interviewed in his home in December 1972 by R. Gray.



HOFFMAN RESIDENCE

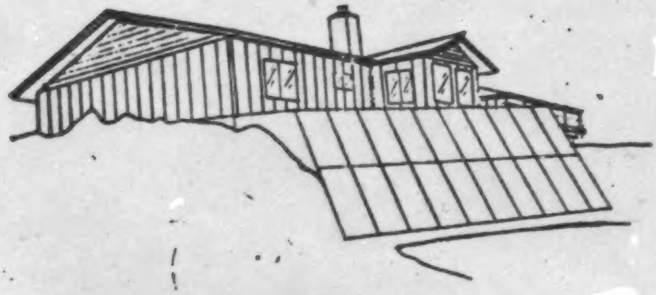
5.3

Building name: TROY ERWIN RESIDENCE
Author: Troy Erwin
Date: 1975
Use of building: Residence
Duration of operation:
Location: Glide, Oregon
Latitude: 44°N
Altitude: 1000 ft. Approx.
Normal degree-days/year: 4088
Ave. Jan. solar intensity on horizontal surface: 102 ly/Day (Corvallis, Oregon)
Minimum design temperature: 20°F
Ave. Jan. temperature: 30°F
Building, floor area heated: 480 sq. ft.
Number of heated levels:
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Hot Water
Position, orientation, tilt above horizontal:
Area: 210 sq. ft.
Reflector, area and slope: 168 sq. ft.
Type of heat transfer surface: Galv. roofing painted black & 3/4" steel pipe
Glazing: Single glass
Cost:
Freeze protection: Anti-freeze solution
Storage, type: Water
Volume: 1000 gal.
Weight:
Water equivalent:
Container: Insulated tank inside collector Building
Heat capacity:
Normal maximum temperature:
Jan. storage in days:
Auxiliary energy supply, type:
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: Circulating Water
Motor requirement: Car Radiator with fan
Transfer to rooms:
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyrheliometer on site:
Cooling:
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance:

Building name: CARROL HOUSE
Author: Roy Josi
Date: 11/17/75
Use of building: Residence
Duration of operation:
Location: Banks, Oregon
Latitude: 45.6°N
Altitude: 2.00 ft.
Normal degree-days/year: 4792
Ave. Jan. solar intensity on horizontal surface: 102 ly/Day
Minimum design temperature: 15°
Ave. Jan. temperature: 38°
Building, floor area heated: 2078 Sq. Ft.
Number of heated levels: 1
Windows: 367 sq. ft. Double glazed
Walls: 2012 sq. ft.; R-11
Roof: 2078 sq. ft. Wood Shingle Attic; R-19
Indoor design temperature: 70°
Design (max.) heat load: 44,092 BTU/HR
Ave. Jan. heat load: 25,653 BTU/HR
Btu required per degree day: 13578 (NEMA Constant 17)
Total winter demand: 65,065,776 Total, 41,708,831 Actual, Difference supplied by Heat Pump
Collector, type, heat transfer fluid: Revere Single Glazed Copper Collector, Water
Position, orientation, tilt above horizontal: South 60°
Area: 390 sq. ft.
Reflector, area and slope: None
Type of heat transfer surface: Copper
Glazing: Single
Cost: $8.00/sq.ft.
Freeze protection: Gravity drain
Storage, type: Water
Volume: 6250 gal., 1250 gal. Aux.
Weight: 51,875 lbs., 10,375 lbs. Aux.
Water equivalent:
Container: Fiberglass
Heat capacity: 1,815,625 BTU, 363,125 BTU Aux. (95°F Max.)
Normal maximum temperature: 100°F
Jan. storage in days: 3.5 days
Auxiliary energy supply, type: Electric Boiler Charging 1250 gal. Tank
Capacity: 18KW
Mode of supply to system: Water to Air Heat Pump
Heat collection and distribution:
Transfer to storage: Water Pump
Motor requirement: ¼ HP, 115V
Transfer to rooms: Water to Air Heat Pump
Motor requirement: ¼ HP, 115V, Heat Pump Total 5.99 KW
Collector flow rate: 7-9 gpm
House flow rate: 12 gpm
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats: Rho-Sigma Model 104 Differential Thermostat
Automatic control of auxiliary: Time clock
Automatic valves and dampers: 5-3 Way Valves to effect Heating/Cooling Change over from Thermostat
Heating direct from collector: No Provision Change from Solar to Aux. using an agrastat
Automatic data recording: Datel Digital Data Logger, 32 Channels, 15 minute Intervals
Pyroheliometer on site: No, 2 Pyranometers (Horizontal, 60°)
Cooling: 4 ton Singer water to air heat Pump
Heat disposal method: Rejection from Heat Pump to Water Storage Tanks, Night Re-radiation by Collectors
Auxiliary cooling: None
Power required: 4.36 KW at 95°
Heat removal from rooms: Forced Air
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 56% Heating Requirements Supplied by Solar Energy

Bibliography

Personal Correspondence

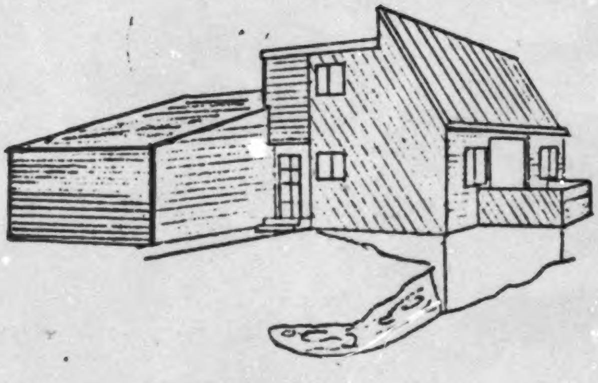


CARROL HOUSE

Building name: BOYLEN HOUSE
Author: Roy Josi
Date: 11/17/75
Use of building: Residence
Duration of operation:
Location: Gladstone, Oregon
Latitude: 45.6°N
Altitude: 290 ft.
Normal degree-days/year: 4792
Ave. Jan. solar intensity on horizontal surface: 102 ly/Day
Minimum design temperature: 15°F
Ave. Jan. temperature: 38°F
Building, floor area heated: 1790 sq. ft.
Number of heated levels: 2
Windows: 210 sq. ft. glazed
Walls: 2378 sq. ft.; R-19
Roof:
Indoor design temperature: 70°
Design (max.) heat load: 31,350 BTU/HR
Ave. Jan. heat load: 18,240 BTU/HR
Btu required per degree day: 9400 (NEMA Constant 17) 13,680
Total winter demand: 45,244,800 BTU
Collector, type, heat transfer fluid: 25% Glycol-water
Position, orientation, tilt above horizontal: South 60°
Area: 429 sq. ft.
Reflector, area and slope: None
Type of heat transfer surface: Revere Copper
Glazing: Double
Cost: $7.80/sq.ft.
Freeze protection: Closed System with 25% Glycol Solution
Storage, type: Water
Volume: 3750 gal., 1250 gal. Aux.
Weight: 31,125 lbs., 10,375 lbs. Aux.
Water equivalent:
Container: 1250 gal. Fibreglass
Heat capacity: 1,867,500 BTU, 622,500 BTU Aux.
Normal maximum temperature: 140°F
Jan. storage in days: 5.7 days
Auxiliary energy supply, type: Electric Boiler Charging 1250 gal. Water Tank
Capacity: 24KW
Mode of supply to system: Heating Coil in Ductwork
Heat collection and distribution:
Transfer to storage: Water to Water Heat Exchanger & Heating Coil in Ductwork
Motor requirement: 3/4 HP, 230V, 1/6 HP, 116V
Transfer to rooms: 2 Heating Coils in Ductwork
Motor requirement: 1/3 HP 115V, 1/6 HP 115V
Collector flow rate: 10-22 gpm
House flow rate: 10-20 gpm
Hot water supply: to be added
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats: Rho-Sigma 104 Differential Thermostat
Automatic control of auxiliary: Time Clock, Thermostat & Aquastat
Automatic valves and dampers: Discharge Reset Thermostat & Aquastat
Heating direct from collector: Yes
Automatic data recording: Datel Digital Datalogger, 32 Channels, 15 Intervals
Pyroheliometer on site: No, 2 Pyranometers (Horizontal 60°)
Cooling: None
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 53%

Bibliography

Personal Correspondence



BOYLEN HOUSE

5.6

- **Building name:** TERA I
- **Author:** Skidmore, Owings and Merrill
- **Date:** June, 1976
- **Use of building:** Experimental and Exhibition
- **Duration of operation:** under construction
- **Location:** Oregon Museum of Science and Industry Portland, Oregon
  - **Latitude:** 45°N
  - **Altitude:** 670 Ft.
  - **Normal degree-days/year:** 4635
  - **Ave. Jan. solar intensity on horizontal surface:** 101 ly/Day Corvallis, Oregon
  - **Minimum design temperature:** 27°F
  - **Ave. Jan. temperature:** 45.6°F
- **Building, floor area heated:** 1050 Sq. Ft.
  - **Number of heated levels:** 2
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:** 70°F
  - **Design (max.) heat load:** 35,800 BTUH (a)
  - **Ave. Jan. heat load:** 20,300 BTUH (a)
  - **Btu required per degree day:** 20,000 BTU
  - **Total winter demand:** 92,700,000 BTU (a)
- **Collector, type, heat transfer fluid:** Hot Air
  - **Position, orientation, tilt above horizontal:** 70°, 12°W. of S.
  - **Area:** 240 Sq. Ft.
  - **Reflector, area and slope:** None
  - **Type of heat transfer surface:** Dimpled Sheet Metal with baked 3M High Temp Paint
  - **Glazing:** Double Glazing W/vacuum space
  - **Cost:**
  - **Freeze protection:** None
- **Storage, type:** 3 tanks, Water Storage
  - **Volume:** 250 gal. tank, 2-510 gal. tanks
  - **Weight:**
  - **Water equivalent:**
  - **Container:**
  - **Heat capacity:**
  - **Normal maximum temperature:**
  - **Jan. storage in days:** 1 Day
- **Auxiliary energy supply, type:** Elec. Boiler
  - **Capacity:** 5 KW
  - **Mode of supply to system:**
- **Heat collection and distribution:** Forced Air
  - **Transfer to storage:** Dampers in Collector with Heat Exchanger to storage tanks
  - **Motor requirement:**
  - **Transfer to rooms:** Forced Air
  - **Motor requirement:**
  - **Collector flow rate:** 1650 CFM
  - **House flow rate:** 1650 CFM; 9 GPM Water
- **Hot water supply:** Preheat
  - **Auxiliary heat:**
  - **Solar source:**
  - **Transfer means:**
- **Automatic controls:**
  - **Collector and storage thermostats:**
  - **Automatic control of auxiliary:**
  - **Automatic valves and dampers:**
  - **Heating direct from collector:**
  - **Automatic data recording:**
  - **Pyroheliometer on site:**
- **Cooling:** Heat Pump
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:**
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:**
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:**
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:** 50% of load

Other Comments:

(a) Calculated by R. Lorenzen

BIBLIOGRAPHY
PERSONAL CORRESPONDENCE

5.7

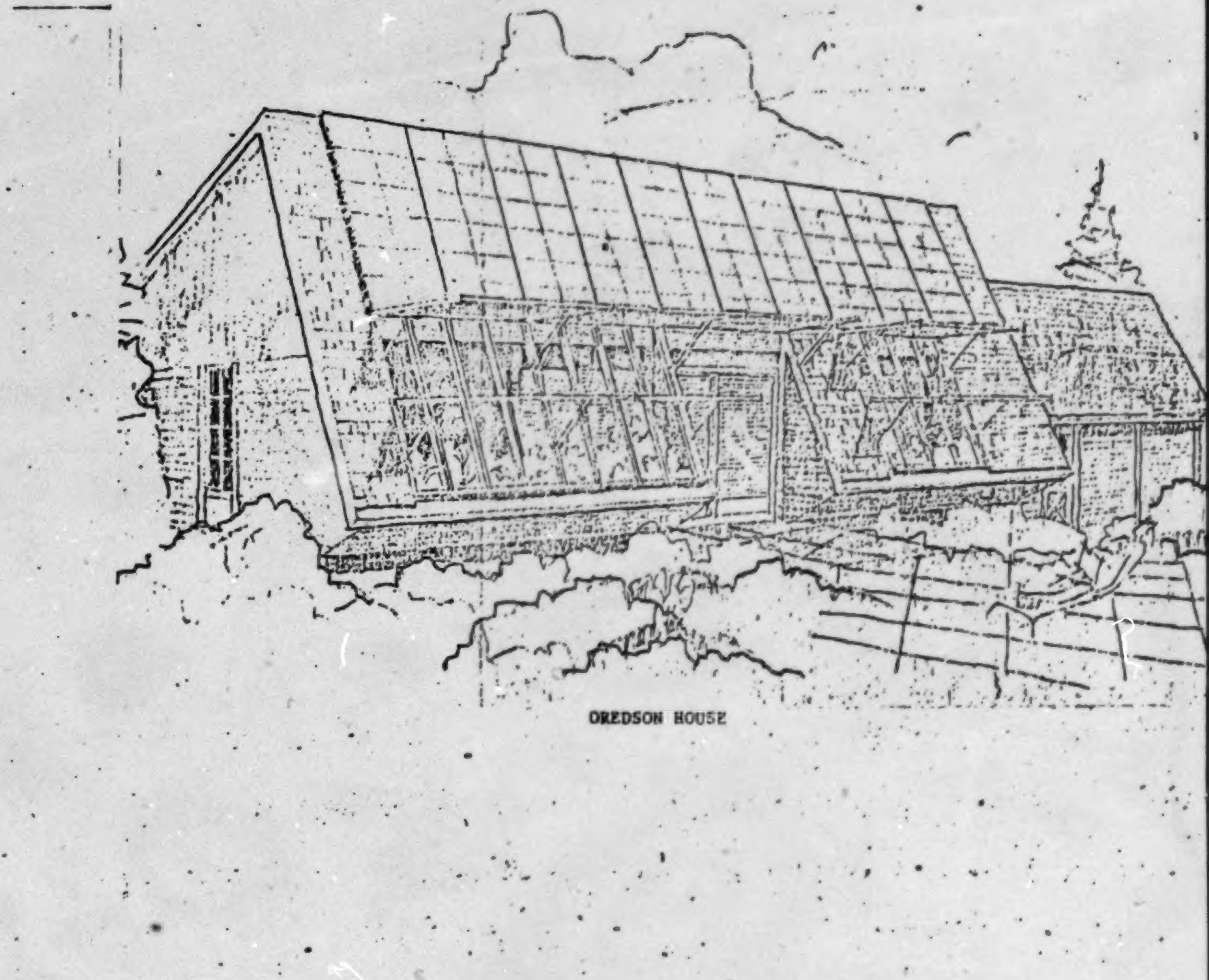
Building name: OREDSON HOUSE
Author: Victor Oredson
Date: November 1975
Use of building: Residence
Duration of operation: under construction
Location: Ashland, Oregon
Latitude: 42^{O}N
Altitude: 1950 Ft.
Normal degree-days/year: 5008
Ave. Jan. solar intensity on horizontal surface: 84 ly/Day Roseburg, Oregon
Minimum design temperature: 10^{O}F
Ave. Jan. temperature: 43.2^{O}F
Building, floor area heated: 1500 Sq. Ft.
Number of heated levels: 1
Windows:
Walls:
Roof:
Indoor design temperature: 72^{O}F
Design (max.) heat load: 58,125 BTUH (a)
Ave. Jan. heat load: 27,000 BTUH (a)
Btu required per degree day: 22,500 BTU
Total winter demand: 112,680,000 BTU (a)
Collector, type, heat transfer fluid: Hot Water Flate Plate and Passive
Position, orientation, tilt above horizontal: 60° South Facing
Area: 320 Sq. Ft.
Reflector, area and slope: 128 Sq. Ft., Reflector is top surface of Passive Window Sun Shades, slope is adjustable
Type of heat transfer surface: Black Silicone
Glazing: Double
Cost: $3200.00
Freeze protection: Night Time Drainage
Storage, type: Water
Volume: 2000 gal.
Weight: 16,720 lbs.
Water equivalent: Same
Container:
Heat capacity:
Normal maximum temperature:
Jan. storage in days: 2-3 Days
Auxiliary energy supply, type: Forced Air Electric
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: Water
Motor requirement:
Transfer to rooms: Forced Air
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply: Preheat coil in storage tank
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats: Total controls by Automated System
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling: None
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 75-85%

Other Comments:

(a) Calculated by R. Lorenzen

BIBLIOGRAPHY

PERSONAL CORRESPONDENCE



OREDSON HOUSE

5.8

Building name: KNOLL HOUSE
Author: Solar Unit designed by Larry McGaugh
Date: April 1976
Use of building: Residence
Duration of operation: under construction
Location: Bend, Oregon
Latitude: 44°N
Altitude: 3600 Ft.
Normal degree-days/year: 6957
Ave. Jan. solar intensity on horizontal surface: 143 ly/Day Redmond, Oregon
Minimum design temperature: -30°F
Ave. Jan. temperature: 35.9°F
Building, floor area heated: 1500 Sq. Ft.
Number of heated levels: 1
Windows:
Walls:
Roof:
Indoor design temperature: 72°F
Design (max.) heat load: 114,580 BTUH (e)
Ave. Jan. heat load: 41,360 BTUH (e)
Btu required per degree day: 27,500 BTU
Total winter demand: 191,317,500 BTU (e)
Collector, type, heat transfer fluid: Hot Water
Position, orientation, tilt above horizontal: 60° South Facing
Area: 496 Sq. Ft.
Reflector, area and slope: None
Type of heat transfer surface: Black Silicone
Glazing: Double
Cost: $4,760.00
Freeze protection: Night time drainage
Storage, type: Water
Volume: 2000 Gal.
Weight: 16,720 lbs.
Water equivalent: Same
Container:
Heat capacity:
Normal maximum temperature:
Jan. storage in days: 2-3 Days
Auxiliary energy supply, type:
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: Water
Motor requirement:
Transfer to rooms: Hydronic (forced hot water), 3-Zone System
Motor requirement:
Collector flow rate:
House flow rate:
Hot water supply:
Auxiliary heat:
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats: Total controls by Automated System
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling: None
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 75-85%

Other Comments:

(a) Calculated by R. Lorenzen

The Knoll House is the first unit of a planned development of solar homes in Bend, Oregon. As of May, 1976 ground had been broken on 8 additional units, with 111 more units planned for construction.

BIBLIOGRAPHY

PERSONAL CORRESPONDENCE

5.9

Building name: MORAVICK RESIDENCE
Author: Tony and Hilda Moravick, Fred Keppel and Steve Baker
Date: May, 1976
Use of building: Residence
Duration of operation: Under Construction
Location: Stayton, Oregon
Latitude: 45°N
Altitude: 450 Ft.
Normal degree-days/year: 4754
Ave. Jan. solar intensity on horizontal surface: 101 ly/Day Corvallis, Oregon
Minimum design temperature: 15°F
Ave. Jan. temperature: 45.4°F
Building, floor area heated: 2200
Number of heated levels: 1
Windows:
Walls:
Roof:
Indoor design temperature: 70°F
Design (max.) heat load: 89,375 BTUH (a)
Ave. Jan. heat load: 39,975 BTUH (a)
Btu required per degree day: 39,000 BTU
Total winter demand: 185,406,000 BTU (a)
Collector, type, heat transfer fluid: Hot Air
Position, orientation, tilt above horizontal: 60° on South facing retaining wall detached from house.
Area: 1000 Sq. Ft.
Reflector, area and slope: None
Type of heat transfer surface: Corrugated Black Metal
Glazing: Double Glazed
Cost: $4500
Freeze protection: None
Storage, type: 2½" Gravel
Volume: 5000 Cu. Ft.
Weight: 500,000 lbs.
Water equivalent: 11,950 gal.
Container:
Heat capacity: 121,000 BTU
Normal maximum temperature:
Jan. storage in days: 5 Days
Auxiliary energy supply, type: Electric resistance
Capacity:
Mode of supply to system:
Heat collection and distribution:
Transfer to storage: Hot Air circulated through rock storage
Motor requirement: 1 1/3 HP
Transfer to rooms: Hot Air from storage
Motor requirement: 1 HP
Collector flow rate:
House flow rate:
Hot water supply: Preheat from collectors; 2 separate tanks, one winter use, one summer use
Auxiliary heat: Electric
Solar source:
Transfer means:
Automatic controls:
Collector and storage thermostats: System uses 2 thermostats, one actuates dampers for convection, one actuates blower when convection insufficient
Automatic control of auxiliary:
Automatic valves and dampers:
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling: Storage is cut off from collector flow, which is used for Hot water preheat
Heat disposal method: convection of night air through storage
Auxiliary cooling:
Power required:
Heat removal from rooms: Air circulation
Performance:
Period:
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar:
Expected (theoretical) performance: 60-65%

Other Comments:

(a) Calculated by R. Lorenzen

BIBLIOGRAPHY

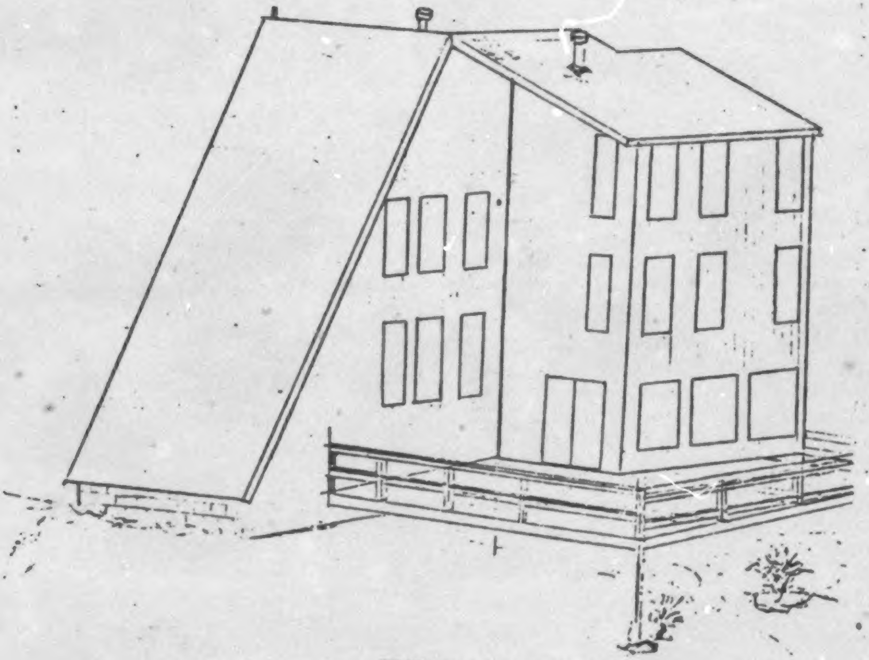
PERSONAL CORRESPONDENCE

5.10

Building name: FRANCIS RESIDENCE
Author: Richard Francis
Date: May 20, 1976
Use of building: Residence
Duration of operation:
Location: Chiloquin, Oregon
Latitude: 42°N
Altitude: 4400 Ft.
Normal degree-days/year: 7000
Ave. Jan. solar intensity on horizontal surface: 150 ly/Day
Minimum design temperature: 0°F
Ave. Jan. temperature: 10°F
Building, floor area heated: 1998 Sq. Ft.
Number of heated levels: 5
Windows: 425 Sq. Ft.
Walls: 1" Board and Batton, 15# paper, 3/8" ply 2 4 studs W/R11 insulation 1/2" plaster board
Roof: Cedar shingles, 30# paper, 6" R19 insulation
Indoor design temperature: 65°F
Design (max.) heat load:
Ave. Jan. heat load:
Btu required per degree day:
Total winter demand:
Collector, type, heat transfer fluid: Hot Water
Position, orientation, tilt above horizontal: 21°W. of S.
Area: 713 Sq. Ft.
Reflector, area and slope: None
Type of heat transfer surface: Aluminum Siding W/Copper Tubing
Glazing: Double 3/16 Glass
Cost: Approx. $2500
Freeze protection: Free Drain
Storage, type: Water
Volume: 9100 gal.
Weight: 76,000 lbs.
Water equivalent: Same
Container: 2 8 X 8 X 10 Steel tanks
Heat capacity: 5.82 X 10^6 BTU
Normal maximum temperature: 160°
Jan. storage in days: 5 Days
Auxiliary energy supply, type: Wood
Capacity: 65,000 BTU/Hr
Mode of supply to system: Forced Air
Heat collection and distribution:
Transfer to storage: Copper Pipes
Motor requirement: 1/3 HP
Transfer to rooms: Forced Air
Motor requirement: 1/16 HP
Collector flow rate: 16 GPM
House flow rate:
Hot water supply:
Auxiliary heat: 40 gal. Water Heater
Solar source: 20 gal. coil submersed in one of the steel storage tanks
Transfer means: 3 HP submersible pump
Automatic controls:
Collector and storage thermostats:
Automatic control of auxiliary: None
Automatic valves and dampers: None
Heating direct from collector:
Automatic data recording:
Pyroheliometer on site:
Cooling:
Heat disposal method:
Auxiliary cooling:
Power required:
Heat removal from rooms:
Performance:
Period: Expected completion date Fall of 1977
Ave. collector efficiency while operating:
Ave. collector efficiency, total radiation:
Total winter heat supply by solar:
Auxiliary energy supply:
Heat equivalent of auxiliary:
Percent load supplied by solar: Expect 75% Solar Heat, 25% Wood
Expected (theoretical) performance:

BIBLIOGRAPHY

PERSONAL CORRESPONDENCE



FRANCIS RESIDENCE

6.1

Building name: Brisbane Solar House
Author: Research Committee on Solar Energy and Tropical Housing, University of Queensland
Date: Completed 1966
Use of building:
Duration of operation:
Location: University of Queensland, Brisbane, Australia
  Latitude:
  Altitude:
  Normal degree-days/year:
  Ave. Jan. solar intensity on horizontal surface: 400 Btu/sf. day (summer)
  Minimum design temperature:
  Ave. Jan. temperature:
Building, floor area heated: 1,318 sqft. cooled (58' x 24') floor, free standing roof 40' x 80'
  Number of heated levels: One storey, 8', 23.5% wall area is double glass
  Windows:
  Walls:
  Roof:
  Indoor design temperature: 78°F (cooling to 70-73°F was common)
  Design (max.) heat load:
  Ave. Jan. heat load: Cooling load of 1 ton
  Btu required per degree day:
  Total winter demand:
Collector, type, heat transfer fluid: Water
  Position, orientation, tilt above horizontal: Roof, 10° slope, facing north
  Area: 64 sqft. (4' x 16') (room for 16 on roof = 1,000 sqft.)
  Reflector, area and slope:
  Type of heat transfer surface: Selective black copper with soldered copper 1/2" dia. tubes, 6" o.c.
  Glazing: Double glass, 3" urathane foam back
  Cost:
  Freeze protection:
Storage, type:
  Volume: 70 gal. hot water tank and 30 tons 3/4" gravel in cold air stream
  Weight:
  Water equivalent:
  Container:
  Heat capacity:
  Normal maximum temperature:
  Jan. storage in days:
Auxiliary energy supply, type: Yes, electric
  Capacity: Variable flow, heated to same temperature as collector output
  Mode of supply to system: Bypass "amplifier" to collector, to simulate additional collector area
Heat collection and distribution:
  Transfer to storage:
  Motor requirement:
  Transfer to rooms: Heating coil in bypass on air duct
  Motor requirement:
  Collector flow rate:
  House flow rate: 1,500 CFM air
Hot water supply:
  Auxiliary heat:
  Solar source:
  Transfer means:
Automatic controls: Yes (seven modes of operation)
  Collector and storage thermostats: Collector, storage, room, and excess imput heat above refrigerator demand
  Automatic control of auxiliary:
  Automatic valves and dampers:
  Heating direct from collector:
  Automatic data recording: Yes, flow and temperature
  Pyroheliometer on site: Yes
Cooling: Solar driven lithium bromide-water absorption cooler[a]
  Heat disposal method: Cross flow cooling tower
  Auxiliary cooling:
  Power required: 194°F start-up, 173°F operation (supply and temperature) (refrigerant at 150°F)
  Heat removal from rooms: Air, 1500 CFM, across evaporation coil
Performance:
  Period:
  Ave. collector efficiency while operating: Collector 32% efficient, refrigerator C.O.P. 0.65, over
  Ave. collector efficiency, total radiation: solar to cooling was 20%
  Total winter heat supply by solar:
  Auxiliary energy supply:
  Heat equivalent of auxiliary:
  Percent load supplied by solar:
  Expected (theoretical) performance:

Other Comments:

(a) 3-tan commercial unit, produces 100-600 Btu/min with water temperatures up to 200° F. Coefficient of performance is 0.68 (varied 0.5 to 0.7)

(b) 720 SF collector could produce 1 tan cooling.

(c) 700 SF collector could cool 1300 SF hours in Brisbane.

(d) 5 cu. ft. storage of refrigerant within refrigerator is reccomended. 1 to 2 days storage in moderate weather.

(e) modified pump, vapor lift for better start up.

Bibliography

Sheridan, Norman, R., "Performance of the Brisbane Solar House", Solar Energy 1972, volume 13, pages 395-401, Pergamon Press, Great Britian.

6.2

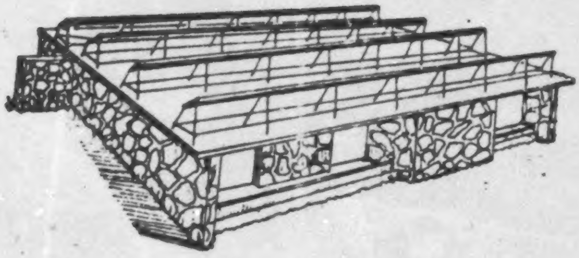
- **Building name:** Giza Solar House
- **Author:** H.H. Safwat and A.F. Sonka
- **Date:** Proposed first in 1962
- **Use of building:**
- **Duration of operation:**
- **Location:** Giza, Egypt (suburb of Cairo)
  - **Latitude:** 30°N
  - **Altitude:**
  - **Normal degree-days/year:**
  - **Ave. Jan. solar intensity on horizontal surface:** (300 almost cloudless days annually)
  - **Minimum design temperature:** (Normal daytime low 50°F)
  - **Ave. Jan. temperature:** (Heating season is November through March)
- **Building, floor area heated:** 2,500 sqft.[a]
  - **Number of heated levels:**
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:**
  - **Design (max.) heat load:**
  - **Ave. Jan. heat load:**
  - **Btu required per degree day:**
  - **Total winter demand:** 4,820,000 Btu.
- **Collector, type, heat transfer fluid:** Water
  - **Position, orientation, tilt above horizontal:** 45°
  - **Area:** 370 sqft.
  - **Reflector, area and slope:** Yes, 870 sqft., 27° slope, adds 50% at noon
  - **Type of heat transfer surface:**
  - **Glazing:**
  - **Cost:**
  - **Freeze protection:**
- **Storage, type:** Two water storage tanks, one hot, one cold, 9,000 gal. each
  - **Volume:** 9,000 gal. total, mora back and forth between two tanks
  - **Weight:** 75,000 lb.
  - **Water equivalent:** Same
  - **Container:** Concrete, insulated, hot water under roof
  - **Heat capacity:** 270,000 Btu.
  - **Normal maximum temperature:** Hot tank, 110°F; cold tank, 78°F
  - **Jan. storage in days:**
- **Auxiliary energy supply, type:** Yes, electric
  - **Capacity:**
  - **Mode of supply to system:** Electric immersion heater, water from cold tank is heated and pumped to hot tank
- **Heat collection and distribution:**
  - **Transfer to storage:** Pump
  - **Motor requirement:** Pump, variable flow, 4,200 lb/hr
  - **Transfer to rooms:** Radiator
  - **Motor requirement:** Pump, variable flow
  - **Collector flow rate:** 120 lb/hr per collector max.; 10 lb/hr min.
  - **House flow rate:** Variable
- **Hot water supply:** No
  - **Auxiliary heat:**
  - **Solar source:**
  - **Transfer means:**
- **Automatic controls:** Full
  - **Collector and storage thermostats:** Collector and room
  - **Automatic control of auxiliary:** Yes
  - **Automatic valves and dampers:** Yes
  - **Heating direct from collector:** No
  - **Automatic data recording:**
  - **Pyroheliometer on site:**
- **Cooling:** No
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:**
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:**
  - **Total winter heat supply by solar:** Anticipated 2,410,000 Btu.
  - **Auxiliary energy supply:** Electricity
  - **Heat equivalent of auxiliary:** Anticipated 2,410,000 Btu.
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:** 50% of heat supplied by solar

Other Comments:

(a) Proposed house would have stone walls and reinforced concrete floor and roof with the hot storage tank hung under the roof and the cool tank under the floor.

Bibliography

Sofwat, H. H., and Souka, A. F., "Design of a New Solar-Heated House Using Double-Exposed Flat-Plate Collectors", Solar Energy, Volume 13, Pergamon Press, Grezt Britian, pages 105-109.



GIZA SOLAR HOUSE

6.3

- **Building name:** St. George's School
- **Author:** A.E. Morgan
- **Date:** 1961
- **Use of building:** Annex to school for 300 students, assumes 14 classrooms
- **Duration of operation:**
- **Location:** Wallasey, Cheshire, England
  - **Latitude:** 53°N
  - **Altitude:** Near sea level, at mouth of River Mersey, maritime climate, windy, cloudy winters
  - **Normal degree-days/year:**
  - **Ave. Jan. solar intensity on horizontal surface:** 120 W/m² floor/day max., cloudy 60 W/m²/day, dense clouds 0 W/m²/day
  - **Minimum design temperature:**
  - **Ave. Jan. temperature:**
- **Building, floor area heated:** 15,410 sqft. = 8,510 upper floor plus 6,900 lower floor. Additional 1,380 sqft. is heated by north glass wal
  - **Number of heated levels:** Two storeys, long-thin, running east-west,
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:**
  - **Design (max.) heat load:**
  - **Ave. Jan. heat load:**
  - **Btu required per degree day:**
  - **Total winter demand:**
- **Collector, type, heat transfer fluid:** Direct (some air)
  - **Position, orientation, tilt above horizontal:** Vertical glass wall, due south
  - **Area:** 6,210 sqft. (27' x 230')
  - **Reflector, area and slope:** None
  - **Type of heat transfer surface:** Concrete, plastered brick, occupants
  - **Glazing:** Two layers of glass, 24" separation
  - **Cost:**
  - **Freeze protection:**
- **Storage, type:** High thermal mass walls 9" brick with plaster, roof 7" concrete, 2nd floor 9" concrete, 1st
  - **Volume:** 17,520 cuft. concrete, 7,360 cuft. brick and plaster floor
  - **Weight:** 3,336,000 lb.
  - **Water equivalent:** 670,000 lb. water = 80,000 gal.
  - **Container:** 5" expanded polystyrene on exterior masonry walls and roof
  - **Heat capacity:** 2.0 million Btu. at Δt = 3°F; 6.7 million Btu. at Δt = 10°F
  - **Normal maximum temperature:**
  - **Jan. storage in days:** At one air change per hour, the thermal lag is one week, interior to climate
- **Auxiliary energy supply, type:** None, except occupants and lighting; occupants add 21.5 W/m² floor/day, lights add 38 W/m²/day, winter
  - **Capacity:**
  - **Mode of supply to system:**
- **Heat collection and distribution:**
  - **Transfer to storage:**
  - **Motor requirement:**
  - **Transfer to rooms:**
  - **Motor requirement:**
  - **Collector flow rate:**
  - **House flow rate:**
- **Hot water supply:**
  - **Auxiliary heat:**
  - **Solar source:**
  - **Transfer means:**
- **Automatic controls:**
  - **Collector and storage thermostats:**
  - **Automatic control of auxiliary:**
  - **Automatic valves and dampers:**
  - **Heating direct from collector:**
  - **Automatic data recording:** Yes, Dr. M.G. Davies, Thermal Research Group, Department of Building Scienc Liverpoor University
  - **Pyroheliometer on site:** Yes, same
- **Cooling:**
  - **Heat disposal method:**
  - **Auxiliary cooling:**
  - **Power required:**
  - **Heat removal from rooms:**
- **Performance:** Maximum temperature fluctuation of ceiling on sunny winter day was 1.6°C
  - **Period:**
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:** Maximum temperature fluctuation on sunny winter day was 1.6°C
  - **Total winter heat supply by solar:**
  - **Auxiliary energy supply:**
  - **Heat equivalent of auxiliary:**
  - **Percent load supplied by solar:**
  - **Expected (theoretical) performance:**

Other Comments:

(a) calculated by R. Gray : concrete = 140 lb./cu.ft., Brick = 120 lb./cu. ft., specific heat = 0.2.

Bibliography

Moorcraft, Colin, "Solar Energy in Housing", Architectural Design, October, 1973, page 656.

Other References:

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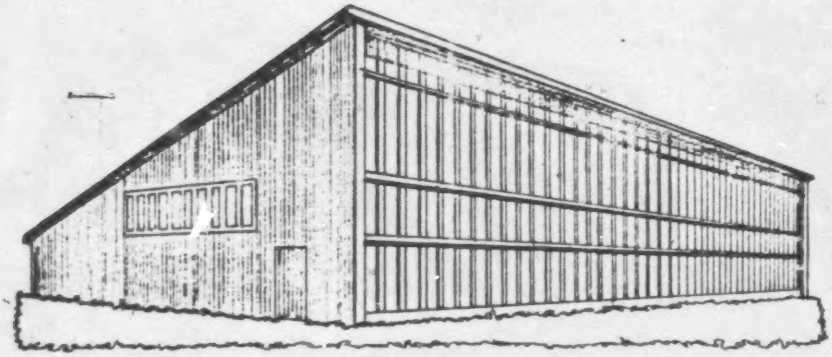


ST. GEORGE'S SCHOOL

6.4

- **Building name:** Trombe-Michel Solar Wall Home
- **Author:** Professor Trombe, Director of the CNRS Solar Energy Laboratory, Pyrenees; Jacques Michel, architect
- **Date:**
- **Use of building:** Residence (two prototype houses of same design)(a)
- **Duration of operation:**
- **Location:** Montlouis, Pyrenees, France
  - Latitude: 42°37'N
  - Altitude:
  - Normal degree-days/year:
  - Ave. Jan. solar intensity on horizontal surface:
  - Minimum design temperature:
  - Ave. Jan. temperature:
- **Building, floor area heated:** 1,100 sqft. (10,000 cuft.)(b)
  - Number of heated levels: One
  - Windows:
  - Walls:
  - Roof:
  - Indoor design temperature:
  - Design (max.) heat load:
  - Ave. Jan. heat load:
  - Btu required per degree day:
  - Total winter demand:
- **Collector, type, heat transfer fluid:** Concrete wall
  - Position, orientation, tilt above horizontal: Vertical, south wall
  - Area: 580 sqft. plus 190 sqft. of south windows
  - Reflector, area and slope:
  - Type of heat transfer surface: Black paint on concrete (rough cast)
  - Glazing: Two layers of glass
  - Cost: Heating two to three times less expensive than electricity - cost of ammortising the glass, simpler glazing, wall ignored since this structural
  - Freeze protection:
- **Storage, type:** Concrete
  - Volume: 1,970 cuft. (13-3/4" thick wall)
  - Weight: 296,000 lb.
  - Water equivalent: 6,600 gal.
  - Container: None
  - Heat capacity: 550,000 Btu at 10°Δt; 1,100,000 Btu at 20°Δt
  - Normal maximum temperature:
  - Jan. storage in days: One night
- **Auxiliary energy supply, type:**
  - Capacity:
  - Mode of supply to system:
- **Heat collection and distribution:**
  - Transfer to storage: Direct absorption
  - Motor requirement: None
  - Transfer to rooms: Convection; space between glass and wall acts as a thermal chimney
  - Motor requirement: None
  - Collector flow rate: Varies with temperature difference
  - House flow rate: Varies with temperature difference
- **Hot water supply:**
  - Auxiliary heat:
  - Solar source:
  - Transfer means:
- **Automatic controls:**
  - Collector and storage thermostats:
  - Automatic control of auxiliary:
  - Automatic valves and dampers: Manual dampers, top and bottom of collector to room
  - Heating direct from collector: Yes, through storage wall
  - Automatic data recording:
  - Pyroheliometer on site:
- **Cooling:** Yes, solar driven ventilation
  - Heat disposal method: From other side of house under eve collector heat chimney is vented to outside at top, and draws in air
  - Auxiliary cooling: None
  - Power required: None
  - Heat removal from rooms: Ventilation
- **Performance:**
  - Period:
  - Ave. collector efficiency while operating:
  - Ave. collector efficiency, total radiation:
  - Total winter heat supply by solar:
  - Auxiliary energy supply:
  - Heat equivalent of auxiliary:
  - Percent load supplied by solar: 67-75%
  - Expected (theoretical) performance:

Other Comments:

(a) A cheaper, simplified version has been built in Meuse (49° N)

(b) For a well insulated house (K = 0.5), the required collector/volume ratio is 0.16. (area in m^2 and volume in m^3)

(c) Electric utilities in France have prevented houses of this design from being built.

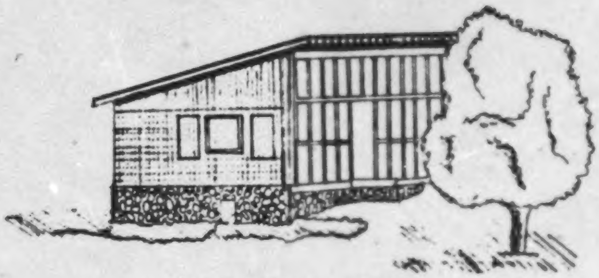
(d) Half the heat absorbed by the wall is stored by it and this is sufficient to maintain a warm air current until the early hours of the morning. The house is too warm on some sunny afternoons and too cool on some cold mornings, but comfortable most of the year.

(e) estimated or calculated by R. Gray, conc. density 140lb./cu. ft.; 0.2 specific heat.

Bibliography

Moorecraft, Colin, "Solar Energy in Housing", Architectural Design, 10/73, pages 652-3.

Shurcliff, William, "Solar-Heated Buildings : A Brief Survey", 1974.



TROMBE-MICHEL SOLAR WALL HOME

6.5

Building name:
Author: Pleijel, Lindstrom
Date:
Use of building: Laboratory
Duration of operation:
Location: Capri, Italy
  Latitude: 41°N
  Altitude: 750 ft.
  Normal degree-days/year: Approx. 2640(a)
  Ave. Jan. solar intensity on horizontal surface: Approx. 125-150 ly/day
  Minimum design temperature: Approx. 30°F(a)
  Ave. Jan. temperature:
Building, floor area heated: 1,940 sqft.
  Number of heated levels: Two(a)
  Windows:
  Walls:
  Roof:
  Indoor design temperature:
  Design (max.) heat load: Approx. 7400 Btuh.(a)
  Ave. Jan. heat load: Approx. 12,000 Btu.(a)
  Btu required per degree day:
  Total winter demand:
Collector, type, heat transfer fluid: Water heating
  Position, orientation, tilt above horizontal: Vertical, south wall
  Area: 320 sqft.
  Reflector, area and slope: None
  Type of heat transfer surface: Metal radiator plates
  Glazing: One plastic, one glass
  Cost:
  Freeze protection:
Storage, type: Water
  Volume: 800 gal.
  Weight: 3.3 tons = 6,680 lb.
  Water equivalent: Same
  Container: Tank
  Heat capacity: 435,000 Btu
  Normal maximum temperature:
  Jan. storage in days:
Auxiliary energy supply, type: Yes, stone and electric resistance
  Capacity:
  Mode of supply to system: Direct to rooms
Heat collection and distribution:
  Transfer to storage: Store hot water
  Motor requirement: Pump, 2 gpm
  Transfer to rooms: Hot water through radiator
  Motor requirement: Pump, 2 gpm
  Collector flow rate: 2.1 gal/min
  House flow rate:
Hot water supply: Proposed separate collector
  Auxiliary heat:
  Solar source:
  Transfer means:
Automatic controls: Partial
  Collector and storage thermostats: Collector and storage
  Automatic control of auxiliary: No
  Automatic valves and dampers: One mixing valve
  Heating direct from collector: No
  Automatic data recording:
  Pyroheliometer on site: Yes
Cooling: Not at present
  Heat disposal method:
  Auxiliary cooling:
  Power required:
  Heat removal from rooms:
Performance:
  Period: Not yet reported
  Ave. collector efficiency while operating:
  Ave. collector efficiency, total radiation:
  Total winter heat supply by solar:
  Auxiliary energy supply:
  Heat equivalent of auxiliary:
  Percent load supplied by solar:
  Expected (theoretical) performance: 50% to 70% of load supplied by solar

Other Comments:

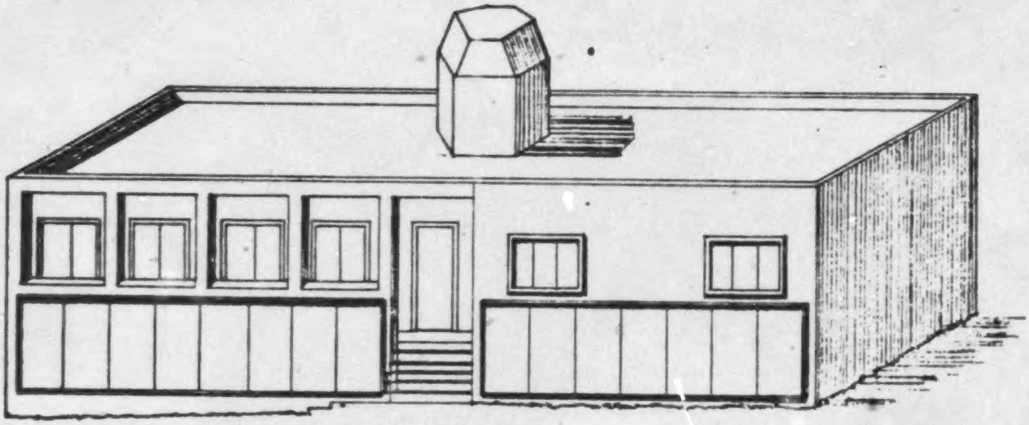
(a) estimated or computed by Löf

(b) All of solar heat supplied to building via storage unit.

(c) calculated by R. Gray at $\Delta t = 65^\circ$ F.

Bibliography

Löf, General Report GR/15 (s), Volume 5, "Proceedings of the U.N. Conference on New Sources of Energy", Rome 1961.



LABORATORY, CAPRI, ITALY

6.6

- **Building name:** Yanagimachi Residence II
- **Author:** Yanagimachi
- **Date:** 1959
- **Use of building:** Residence
- **Duration of operation:**
- **Location:** Tokyo, Japan
  - **Latitude:** 36°N
  - **Altitude:** Approx. 700 ft.
  - **Normal degree-days/year:** 3800
  - **Ave. Jan. solar intensity on horizontal surface:** 288 ly/day
  - **Minimum design temperature:** 32°F
  - **Ave. Jan. temperature:**
- **Building, floor area heated:** 2,460 sqft.
  - **Number of heated levels:** Two
  - **Windows:**
  - **Walls:**
  - **Roof:**
  - **Indoor design temperature:**
  - **Design (max.) heat load:** 25,000 Btuh.
  - **Ave. Jan. heat load:** Approx. 20,000 Btuh.(a)
  - **Btu required per degree day:** 17,000 Btu(a)
  - **Total winter demand:** 64,000,000 Btu
- **Collector, type, heat transfer fluid:** Water heating
  - **Position, orientation, tilt above horizontal:** On south roof, 15° tilt
  - **Area:** 1,410 sqft.(b)
  - **Reflector, area and slope:**
  - **Type of heat transfer surface:** Expanded aluminum tubed sheet
  - **Glazing:** None
  - **Cost:**
  - **Freeze protection:**
- **Storage, type:** Water
  - **Volume:** 9,600 gal.(c)
  - **Weight:** 40 tons
  - **Water equivalent:** Same
  - **Container:** Concrete tank
  - **Heat capacity:** 2.4 million Btu
  - **Normal maximum temperature:** Approx. 70-80°F
  - **Jan. storage in days:**
- **Auxiliary energy supply, type:** Yes, electric heat pump
  - **Capacity:** 3 H.P. compressor motor
  - **Mode of supply to system:** Pump heat from solar tank to hot tank
- **Heat collection and distribution:**
  - **Transfer to storage:** Store warm water
  - **Motor requirement:**
  - **Transfer to rooms:** Hot water in radiant ceiling
  - **Motor requirement:** 3 1/2 H.P. pumps; 1 1/2 H.P. pump
  - **Collector flow rate:**
  - **House flow rate:**
- **Hot water supply:** Yes, full supply
  - **Auxiliary heat:** From 1 H.P. heat pump(d)
  - **Solar source:** Separate 350 sqft. collector
  - **Transfer means:** Via heat pump
- **Automatic controls:** Full
  - **Collector and storage thermostats:** Collector and storage
  - **Automatic control of auxiliary:** Yes
  - **Automatic valves and dampers:** No
  - **Heating direct from collector:** No
  - **Automatic data recording:** Yes
  - **Pyroheliometer on site:** Yes
- **Cooling:** Yes
  - **Heat disposal method:** Night radiation and convection
  - **Auxiliary cooling:** Heat pump
  - **Power required:** 3 H.P.
  - **Heat removal from rooms:** Water in ceiling and air exchanger
- **Performance:**
  - **Period:** Winters, 1959, 1960, 1961
  - **Ave. collector efficiency while operating:**
  - **Ave. collector efficiency, total radiation:** 22%(a)
  - **Total winter heat supply by solar:** 45,000,000 Btu
  - **Auxiliary energy supply:** 5,580 kwh = 19,000,000 Btu
  - **Heat equivalent of auxiliary:** Approx. 63,000,000 Btu
  - **Percent load supplied by solar:** 70%, 42%
  - **Expected (theoretical) performance:**

Other Comments:

(a) estimated or computed by Löf in (1).

(b) space heating and water heating units.

(c) also a 2,700 gallon tank for storage of water warmed by condenser of heat pump.

(d) also a ½ hp heat pump, on solar source, for bath tub heating.

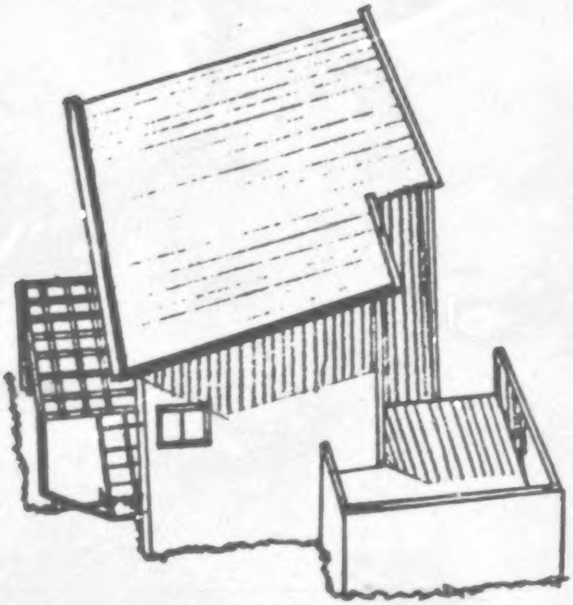
(e) computed by assuming average steam-power plant efficiency at 30%.

(f) based on equal heating effectiveness of work and heat, i.e 1 k Wh = 3,412 btu.

(g) based on note (e) above, the efficiency then being effectively the heat supplied to the house by solar divided by the sum of this quantity plus the heat from fuel burned in an average power plant to produce the required electric energy.

Bibliography

Löf, George, General Report GR/14 (s), Volume 5, "Proceedings of the U.N. Conference on New Sources of Energy", Rome 1961.



YANAGIMACHI RESIDENCE II

6.7

Building name:
Author: Fukuo, and others
Date:
Use of building: Laboratory
Duration of operation:
Location: Nagoya, Japan
Latitude: 36°N
Altitude: Approx. 200 ft.
Normal degree-days/year:
Ave. Jan. solar intensity on horizontal surface: Approx. 275 ly/day(a)
Minimum design temperature:
Ave. Jan. temperature:
Building, floor area heated: 880 sqft.
Number of heated levels: One
Windows:
Walls:
Roof:
Indoor design temperature:
Design (max.) heat load:
Ave. Jan. heat load: 36,000 Btuh(b)
Btu required per degree day: 37,000 Btu(b)
Total winter demand:
Collector, type, heat transfer fluid: Water heating
Position, orientation, tilt above horizontal: On south roof, 35° tilt
Area: 300 sqft.
Reflector, area and slope:
Type of heat transfer surface: Expanded aluminum tubed sheet
Glazing: None
Cost:
Freeze protection:
Storage, type: Water
Volume: 1,480 gal.(c)
Weight: 6.2 tons = 12,400 lb.
Water equivalent: Same
Container: Buried tank
Heat capacity: 0.22 million Btu
Normal maximum temperature: 55°F
Jan. storage in days:
Auxiliary energy supply, type: Yes, electric heat pump
Capacity: 3 H.P. compressor motor
Mode of supply to system: Pump heat from solar tank to hot tank
Heat collection and distribution:
Transfer to storage: Store warmed water
Motor requirement:
Transfer to rooms: Hot water to air heater
Motor requirement: 2 pumps
Collector flow rate: 16 gal/min
House flow rate:
Hot water supply: No
Auxiliary heat: N.A.
Solar source: N.A.
Transfer means: N.A.
Automatic controls: Yes
Collector and storage thermostats: Collector and storage
Automatic control of auxiliary: Yes
Automatic valves and dampers:
Heating direct from collector: No(d)
Automatic data recording: Yes
Pyrobeliometer on site: Yes
Cooling: Yes
Heat disposal method: Night radiation and convection
Auxiliary cooling: Heat pump
Power required: 3 H.P.
Heat removal from rooms: Water through air exchanger
Performance:
Period: November through March average
Ave. collector efficiency while operating: Average January, approx. 54%
Ave. collector efficiency, total radiation:
Total winter heat supply by solar: 14.5 million Btu
Auxiliary energy supply: 1370 kwh = 4.7 million Btu
Heat equivalent of auxiliary: Approx. 15.5 million Btu(a,e)
Percent load supplied by solar: 75%,(f) 48%(a,g)
Expected (theoretical) performance:

Other Comments:

(a) Estimated or computed by Löf in (1).

(b) Design values for heat loss rates per daytime hour. (operated 10 hours per day only) ; and per 24 hour period per °F. difference between 65° F and January average atmospheric temperature of 36.5° F.

(c) Also a 1480 gallon tank for storage of water warmed by condenser of heat pump.

(d) All of the solar heat supplied to building via storage unit, i.e. collector-storage-rooms.

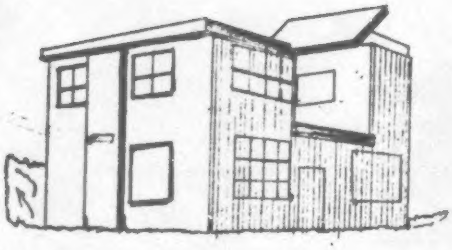
(e)

(f) same as e, f, g in Yanagamachi

(g)

Bibliography

Lof, George, General Report GR/14 (s), Volume 5, "Proceedings of the U.N. Conference on New Sources of Energy, Rome 1961.



FUCUO LABORATORY

Systems Type Cross Index

I Passive Systems

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3.2 Purdue Solar House
4.7 Skytherm Prototype
4.8 Zome
4.11 Skytherm House
6.3 St. Georges School
6.4 Residence by Trombe and Michel

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1.2 MIT Solar House II
1.3 MIT Solar House III
1.5 MIT Solar House IV
1.8 Watson/Barber Solar House
1.10 G. Cleveland Jr. H.S.
1.11 PP&L Energy Conservation House
1.12 Dimetroden Condominium
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1.14 Audubon Society Offices
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2.2 "Solaris" House #2
2.3 "Solaris" House #3
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2.5 A.N. Wilson House
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2.7 Madeire School Science Wing
2.8 NASA Solar House
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4.23 Peter Van Dresser Residence
4.25 Molen House
5.6 Tera I
5.9 Moravick House

REVIEW

SURVEY OF SOLAR BUILDINGS

Is the Data Sheet format easily understood?
How could it be improved?
What data can be deleted, what data could be included?
Is the system cross index a helpful element?
What other type of appendices would be appropriate?

Please send us your observations on these questions and any other comments you may have.

OTHER SOLAR PUBLICATIONS:

Available from the Center for Environmental Research

Baker, M.S. and Reynolds, J.S.
"Insolation on Tilted Surfaces for Pacific Northwest Locations", 54 p., 1975
CER 117 $1.00

Reynolds, J.S.
"Solar Energy for Pacific Northwest Buildings", Fourth Edition, 70 p., 1976
CER 110 $3.00

Reynolds, J.S.; Larson, M.B. and Baker, M.S.
"The Atypical Mathew Solar House at Coos Bay, Oregon", 24 p., 1975
CER 116 $1.00

Students of J.S. Reynolds
"Energy Conservation and Solar Retrofitting for Existing Buildings in Oregon: an Architecture Design Class Project", 122 p., Bound, 1975
CER 118 $3.25

CENTER FOR ENVIRONMENTAL RESEARCH
Department of Architecture
School of Architecture and Allied Arts
University of Oregon
Eugene, OR 97403

- Building name:
- Author:
- Date:
- Use of building:
- Duration of operation:
- Location:
  - Latitude:
  - Altitude:
  - Normal degree-days/year:
  - Ave. Jan. solar intensity on horizontal surface:
  - Minimum design temperature:
  - Ave. Jan. temperature:
- Building, floor area heated:
  - Number of heated levels:
  - Windows:
  - Walls:
  - Roof:
  - Indoor design temperature:
  - Design (max.) heat load:
  - Ave. Jan. heat load:
  - Btu required per degree day:
  - Total winter demand:
- Collector, type, heat transfer fluid:
  - Position, orientation, tilt above horizontal:
  - Area:
  - Reflector, area and slope:
  - Type of heat transfer surface:
  - Glazing:
  - Cost:
  - Freeze protection:
- Storage, type:
  - Volume:
  - Weight:
  - Water equivalent:
  - Container:
  - Heat capacity:
  - Normal maximum temperature:
  - Jan. storage in days:
- Auxiliary energy supply, type:
  - Capacity:
  - Mode of supply to system:
- Heat collection and distribution:
  - Transfer to storage:
  - Motor requirement:
  - Transfer to rooms:
  - Motor requirement:
  - Collector flow rate:
  - House flow rate:
- Hot water supply:
  - Auxiliary heat:
  - Solar source:
  - Transfer means:
- Automatic controls:
  - Collector and storage thermostats:
  - Automatic control of auxiliary:
  - Automatic valves and dampers:
  - Heating direct from collector:
  - Automatic data recording:
  - Pyroheliometer on site:
- Cooling:
  - Heat disposal method:
  - Auxiliary cooling:
  - Power required:
  - Heat removal from rooms:
- Performance:
  - Period:
  - Ave. collector efficiency while operating:
  - Ave. collector efficiency, total radiation:
  - Total winter heat supply by solar:
  - Auxiliary energy supply:
  - Heat equivalent of auxiliary:
  - Percent load supplied by solar:
  - Expected (theoretical) performance: